Enamel and dentine of deciduous teeth
Er:YAG laser prepared. A SEM study

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Abstract: The aim of this study was to observe dentine and enamel surfaces of deciduous teeth under SEM after cavity preparation with Er:YAG laser using different fluences. The results showed that when using Er:YAG laser for cavity preparation in deciduous teeth, no carbonisation or cracks were observed on the enamel and dentine surfaces using energy output between 150-250 mJ, and frequency 15 Hz. The SEM images of the dentine and enamel surfaces were similar to previous studies on permanent teeth: enamel with a typical “lava flow” appearance as a result of an open core of the prism that has lost its typical hexagonal aspect and the dentine with opened tubules plus a difference in the mineral thickness between peritubular and intertubular. Conclusion: The difference between the SEM images of deciduous enamel and dentine when using three different energies (150-200-250 mJ) is not significant in order to recommend the use of one type of output energy. In addition, the SEM images are similar to those of permanent teeth.

Key words: Er:YAG laser, Deciduous teeth, SEM.

Introduction

Today the Er:YAG laser is used in dentistry mainly for ablation of hard tissues (enamel, dentine and bone), but also for the treatment of soft tissues [Stabholz et al., 2003].

Many papers [Cozean et al., 1997; Brugnera et al. 2001] have reported that Er:YAG laser ablation of enamel and dentine is effective and efficient without any thermal damage to the pulp, and without carbonisation or cracks of the irradiated enamel and dentine. Moreover, many studies [Kornblit et al., 2008; Cavalcanti et al., 2003; Geraldo-Martins et al., 2005; Matsumoto et al., 2007; Yamada et al., 2002] have also shown that the use of the Er:YAG laser for dental hard tissue treatment, like caries removal, cavity preparation, and enamel etching with certain parameters, is both safe and effective.

Literature reports that SEM images of ultrastructural morphological changes in the enamel and dentine of permanent teeth after irradiation with Er:YAG laser show that the enamel surface is similar to a “lava flow” with an open prism core and modification of the prism form. Some studies noticed occasional cracks [Tokonabe et al., 1999; Curti et al., 2004; Souza-Gabriel et al., 2008]. The dentine surface observed under SEM after laser irradiation appears with open dentinal tubules due to the absence of smear layer, and with a difference in the mineral components between the peritubular and the intertubular dentine, the former being more calcified. No signs of carbonisation or evident cracks were observed [Bertaard et al., 2004; Souza-Gabriel et al., 2006; Ceballos et al., 2002].

There are some important enamel and dentine anatomic ultrastructure differences between the permanent teeth and the deciduous ones. The enamel prisms of deciduous teeth do not have an orderly spatial organisation compared to those of permanent teeth. The large superficial crystals are irregular due to post-eruption maturation, and often the enamel is aprismatic, which explains why the colour of deciduous teeth is more opaque. The aprismatic enamel is more frequently found at the interproximal, vestibular and oral aspects of the crown. Moreover, the enamel of deciduous teeth is less mineralised and more porous.

The main difference between the dentine of the permanent and deciduous teeth is related to the size and number of the dentinal tubules. The diameter of the dentinal tubules of permanent teeth ranges from...
0.5 µm to 0.9 µm at the enamel-dentine junction, and it increases up to 2-3 µm near the pulp.

The diameter of the dentinal tubules of deciduous molars instead varies between 1.77 and 1.80 µm.

The number of dentinal tubules per unit area in permanent teeth is around 15,000-20,000/mm² at the enamel-dentin junction, and up to 65,000/mm² close to the pulp, while the number of the dentinal tubules per unit area in the deciduous teeth is lower.

The tubules of the deciduous teeth have a smaller diameter and are more widely spaced compared to the permanent teeth. The dentine of deciduous teeth mineralises mainly during the foetal period, and the process continues after birth, which explains why the inorganic component is less abundant in deciduous teeth [Sturdevant, 2002].

The structural differences of enamel and dentine between deciduous teeth and permanent ones, as described above, makes it important to study at SEM the enamel and dentine surface of deciduous teeth after Er:YAG laser irradiation.

The aim of this study was to observe (at SEM) the dentine and enamel surfaces of deciduous teeth after cavity preparation with Er:YAG laser using different fluences.

**Materials and methods**

Nine teeth extracted for orthodontic reasons, with no decay and/or injuries (fractures?), or previous treatments were selected. The samples were stored in a saline solution at 4°C to avoid dehydration or alteration of the enamel and dentine tissues, for a period not exceeding 21 days. The roots were then included in a resin block to hold the specimen and to ease cavity preparation. The 9 teeth were divided into three groups (Table 1).

In all the first and second deciduous molars a Black’s Class II cavity was prepared including enamel and dentine up to 1-1.5 mm depth.

In the deciduous canines a Class IV cavity was prepared, including once again enamel and dentin, and at the same depth.

All cavities were prepared by the same operator under 2.5 x 350 magnification (Univet medical eyewear), with the laser handpiece kept 0.8-1.2 cm from the tooth surface for ablation in focus mode (Fig. 1).

Cavities were prepared with an Er:YAG laser (Fotona Fidelisplus II) adjusted to the following parameters (Table 2).

The VSP mode (pulse duration: 100 µs) is optimised for ablation of the hardest tissue of the human body (enamel) and have very high instant power. With those very short pulses the chromophores in the enamel (water and hydroxyapatite) will quickly overheat and lead to very high speed ablation.

The handpiece used was a non contact one (mirror) where terminal part the laser beam is reflected by a prism or metal mirror. The energy is transmitted to the dental surface through an optical window with air/water jet flow. The spot size on the target tissue at the focal distance was 0.8 mm.

The exit window was regularly cleaned during treatment by wiping away the debris from ablated material.

For each group a different energy was used:
- Group A: output energy 150 mJ, frequency 15 Hz, fluence 30 J/cm²;
- Group B: output energy 200 mJ, frequency 15 Hz, fluence 40 J/cm²;

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<tr>
<th>Group A</th>
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<td>Second deciduous molar</td>
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**TABLE 1 - Sample selection.**

**TABLE 2 - Laser parameters.**
FIG. 2A, 2B - Sample slicing with abrasive disc.

- Group C: output energy 250 mJ, frequency 15 Hz, fluence 50 J/cm².

After cavity preparation the samples were sliced with special abrasive discs COD: Yellow-Flex 220 (for dental). A vertical cut (mesio-distal) and a horizontal cut (cervical) were performed (Fig. 2).

All the nine samples were dipped for 30 seconds in an ultrasonic bath at 30°C to remove any residual powder deposited after slicing. The samples were then kept in an oven at 40°C for 14 hours in order to remove all traces of moisture as this can interfere with the vacuum needed for metallisation.

All samples were then conventionally metallised (gold sputtering, JEOL JFC 1100E) and observed under SEM (JEOL, JSM 5310LV).

**Results**

*First group - 150 mJ, 15 Hz*

The dentine surface in all the three images (Fig. 3, 4, 5) appears irregular (neither smooth nor uniform) with opened dentinal tubules which
diameters are not strictly identical but always small.

The intertubular dentine (hypomineralised) is ablated more than the peritubular dentine.

No visible cracks or carbonisation can be observed.

In the enamel SEM samples of this group the core as well as the edge of the prisms are destroyed in an undifferentiated way (Fig. 6). No cracks or carbonisation are observed.

Second group - 200 mJ, 15Hz

Enamel. The irradiated enamel (Fig. 8, 9) has a characteristic appearance resembling a lava flow, the same as that of permanent teeth, that is the result of laser irradiation that leaves the enamel surface with an irregular appearance with open enamel prisms, and the irregular aspect of the edge looks like enamel “ready to break”, corresponding to a Silverstone classification type III.

In Figure 7, taken after tilting the sample in the SEM column, we can note the different orientation of the enamel prisms. There are not cracks or carbonisation.

Dentine. In the images of irradiated dentine with 200 mJ (Fig. 10, 11, 12) the surfaces appear more homogeneous, being the difference between intertubular and peritubular dentine less evident.

The dentinal tubules are similarly open, small in diameter, and in reduced number per unit area. Neither cracks nor carbonisation are visible.

Third group - 250MJ 15H

Enamel. When using energy of 250 mJ the
enamel surface is even less regular (Fig. 13, 14) comparing to the previous images: the crystalline structure of the hexagonal form of the prism is lost. The enamel shows the characteristic appearance of a lava flow as a result of the interaction laser-target tissue. The different orientation of the enamel prisms, oblique and longitudinal, is a characteristic of the deciduous enamel and can be clearly seen in Figure 14. When using energy of 250 mJ the enamel surface is even less regular (Fig. 13). No cracks or carbonisation are observed.

Slicing the samples permits to observe the limit between Er:YAG treated and non treated enamel areas (Fig. 15): a regular line is observed, and separation of treated and untreated surfaces is clearly defined.

**Dentine.** When using output energy of 250mJ, no significant differences are observed as compared with previous output energies (Fig, 16, 17, 18).

**Discussion**

The most important observation to be reported is that when using an Er:YAG laser with air/water spray in the range of 150 mJ to 250 mJ neither cracks nor areas of carbonisation were observed on the enamel and dentine surfaces of deciduous teeth.

The enamel SEM images show that the deciduous enamel irradiated with different output energies, has the characteristic appearance of a lava flow, similar to the irradiated enamel of permanent teeth as reported in literature [Ying et al., 2004; Freitas et al., 2007]. This appearance is due to the complete opening of the prism core with a partial distruction of the interprismatic structure. The
irregular aspect of the peripheral enamel is due to the fragility of the prisms that look “ready to break”.

The irregularity of the enamel surface after Er:YAG laser irradiation can be compensated with the application of phosphoric acid that attacks and regularise the previously opened prisms; this way the enamel surface increases the micro-infiltration of the bonding [Ceballos et al., 2002; Freitas et al., 2007].

Analysing the SEM images of the irradiated dentine of the deciduous teeth, we noticed that the dentine surfaces of deciduous teeth are identical to those found in permanent teeth [Delmè, Soares et al., 2007]: irregular with open dentinal tubules of various diameters and different intertubular and peritubular dentine thickness with the typical aspect of a peritubular collar composed of high mineral dentine concentration.

The differences between intertubular and peritubular dentine is not homogeneous for all the samples. This could depend on the exposure time...
were similar to previous studies on permanent teeth: enamel with a typical “lava flow” appearance as result of an open prism with a core that has lost its typical hexagonal form, and dentine with open tubules and different mineral thickness between peritubular and intertubular dentine.

The difference between the SEM images of enamel and dentine when using three different energies (150, 200, 250 mJ) is not significant in order to recommend the use of one energy over another.

**References**


