－ORIGINAL ARTICLE－

Study on Microstructure of Adhesive Interface after Caries Removal by Er：YAG laser

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Abstract：The purpose of this study was to evaluate microstructure of adhesive interface after removal caries by Er：YAG laser. Observation of the micromorophology of adhesive interface was performed by Laser Scanning Microscope（LSM), Scanning Electron Microscope（SEM）and WDX type of electron probe X-ray microanalyzer（EPMA）.

The results were as follows：

1．LSM images on the enamel and dentin cutting surfaces filled by composite resin system

The surface of the enamel cut by the Er：YAG laser system was showing a crack. While surface cut by an air-turbine hand piece was not showing a crack. The dentinal surface by laser irradiation and cut by an air-turbine hand piece did not show a crack.

2．EPMA Analysis on the enamel or dentin interface filled by composite resin system

In SEM image, the cavity prepared by the laser had crack in the enamel. While the cavity prepared by turbine had hardly any cracks. When observed under an SEM, peripheral irregularities were more marked in the laser cut group than in the turbine cut group. The cavity prepared by the laser and turbine showed no cracks in the dentin. EPMA images showed that the decrease of calcium and phosphorus on the enamel and dentin area irradiated by Er：YAG laser were more remarkable than that on surfaces prepared by air-turbine handpiece.

The results of the present investigation suggested that the subsurface layers of the enamel and dentin area irradiated by Er：YAG laser were mechanically weakened due to the formation of structural defects and denatured layer, leading to considerably lower adhesive properties of resin bonding systems.

抄録：本研究では，レーザー照射歯面におけるコンポジットレジンの接着機構を明らかにすることを目的として，Er：YAGレーザーによるう触除去後の接着界面の検討を行った。接着界面の観察は，走査型共焦点レーザー顕微鏡（LSM）およびX線マイクロアナライザー（EPMA）を用いて行われた。

1．コンポジットレジン充填後の歯質切削面のLSMによる観察

エナメル質において，Er：YAGレーザーによる形成窩洞には，クラックが認められたが，タービンを用いた場合には，クラックは認められなかった。象牙質では，Er：YAGレーザーおよびタービンを用いた形成窩洞とも，クラックは認められなかった。

2．コンポジットレジン充填後の接着界面のX線マイクロアナライザーによる観察

SEM像において，Er：YAGレーザーによるエナメル質形成窩洞には，クラックが認められたが，タービンを用いた場合には，クラックは認められなかった。形成窩洞の辺縁は，タービンを用いたものより，レーザーを用いた方が，明らかに不規則であった。象牙質では，Er：YAGレーザーおよびタービンを用いた形成窩洞においては，共に，ク

ラックは認められなかった。EPMA像において，エナメル質および象牙質とも，タービンを用いた形成窩洞よりレーザーを用いた方が，CaとPの濃度の低下を認めた。

以上の結果から，Er：YAGレーザー照射により，エナメル質および象牙質表層に，コンポジットレジンの接着性を阻害する構造の欠陥や変性層が生ずることが示唆された。

INTRODUCTION

The main problem with the conventional caries treatment procedure was the irritation of the patient by the sound and vibration caused by the rotary cutting device. There were also possibilities of friction heat and cracks during cutting by the rotary cutting device. In recent studies, it has been suggested that the application of lasers would solve this problem, resulting in a more comfortable treatment procedure for the patient[1].

In 1975, Zharikov *et al.*[2] developed the Er：YAG laser as a new technical modality for caries treatment. The Er：YAG laser is considered to be less invasive to surrounding tissue because wavelengths selectively absorbed by water in tissue are used, and tissue destruction occurs by the explosive power at the time of instantaneous water vaporization. Furthermore, applying the laser while spraying water reduced the damage caused to non-targeted tissue due to heating, and improved the cutting efficiency. In 1988, Hibst *et al.*[3] indicated that the irradiation of the Er：YAG laser could perform without causing cracks on the irradiation surface. Since then, a number of studies have been conducted on the Er：YAG laser . Clinical trials of the Er：YAG laser for caries treatment have gradually increased. At present, this laser is used clinically not only for the treatment of dental caries, but also for periodontics, endodontics and in other dental disciplines[4-10].

When the Er：YAG laser is used to repair hard tissue affected by caries or other disorders, restorative materials such as composite resin seem to be suitable on the grounds that the surface after laser irradiation is inevitably rough. The surface that Er：YAG laser was irradiated has features favorable for adhesion, e.g., the absence of smears and the presence of a dentinal tubule orifice[11-14]. The surface irregularities created by the laser do not lead to an increase in the bonding area or the formation of smear. These features are expected to favorably affect repair with composite resin, and contribute to improving the bonding strength and border seal. A number of studies have examined the strength of the bonding of composite resin to enamel and dentin laser irradiated[15-17]. Therefore, studying changes in the composition of tooth tissue following application of the Er：YAG laser is useful in developing optimal techniques of restoration following cavity preparation by this laser.

The purpose of this study was to evaluate microstructure of adhesive interface after removal caries by Er：YAG laser. Observation of the micromorophology of adhesive interface was performed by Laser Scanning Microscope （LSM）, Scanning Electron Microscope （SEM） and WDX type of electron probe X-ray microanalyzer （EPMA）.

MATERIALS AND METHODS

Apparatuses

In this study, the used laser apparatus was the Er：YAG laser system（Erwin; Hoya Corp., Tokyo, Japan, and J. Morita Corp., Kyoto, Japan.）. The caries was removed by laser irradiation, using a 0.6 mm diameter tip（FTB-80）and a 0.4 mm diameter tip（FTB-60）, and spraying a mixture of air and water. On the other hand, as a control the caries was removed by rotary cutting device. The used burs were round-burs. Cutting was performed under high-speed water infusion. Cutting conditions are shown in Table 1. Dental adhesive systems and composite resins as restoration materials were used. Materials used are shown in Table 2. By the routine method, pretreatment using Mega-bond system（Kuraray medical inc., Okayama, Japan.）was performed, followed by restoration using Clearfil AP-X（Kuraray medical inc., Okayama, Japan.）.

The following investigations were conducted：

In this study, newly extracted carious teeth that were diagnosed as unpreservable were used. The teeth had caries that extending to the dentin. The caries area of the examined teeth was dyed with the acid red （CARIES DETECTOR; Kuraray medical inc., Okayama, Japan.）. The carious teeth were repeatedly dyed till