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LASER-INDUCED EFFECTS ON TOOTH STRUCTURE I. CRATER PRODUCTION WITH A CO₂-LASER

by

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INTRODUCTION

Structural removal by laser impact has been carried out by several investigators (*Goldman et al.*, 1965; *Kinersly et al.*, 1965; *Fredén et al.*, 1966; *Gordon*, 1967; *Peck & Peck*, 1967; *Varner et al.*, 1967; *Stern & Sognaes*, 1964, 1965; *Stern et al.*, 1966) by using single or multiple focused pulses. Depending on the energy output, the effects thus produced have ranged from minute alterations of the surface structure of dental enamel, to gross craters passing through the enamel and reaching the dentine.

The present paper belongs to a series of communications, carried out in order to elucidate the reactions to lasing in enamel, dentine and in dental pulp. This report, however, deals exclusively with the obvious cratering produced by a continuously operating gas laser.

MATERIAL AND METHOD

Laser Equipment. A CO₂-gas laser (Philips, Eindhoven, Holland) emitting infrared radiation at a wavelength of 10.6 μm , continuous output 50 W, was used in connection with a focusing germanium lens system. By these means, the energy density of the radiation, according to the manufacturer, reached 0.3 MW/cm².

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Tooth Material. The laser beam was focused on the buccal surface of ten intact teeth, kept in distilled water after extraction. The lasing period varied between 1 and 3 seconds.

RESULTS

The application of the continuous infrared laser beam resulted in all cases in the formation of conspicuous craters (Figs. 1—3). Within and at the margin of the craters, the enamel appeared nonglossy and whitish. The surface of the enamel around the crater exhibited severe burning, especially

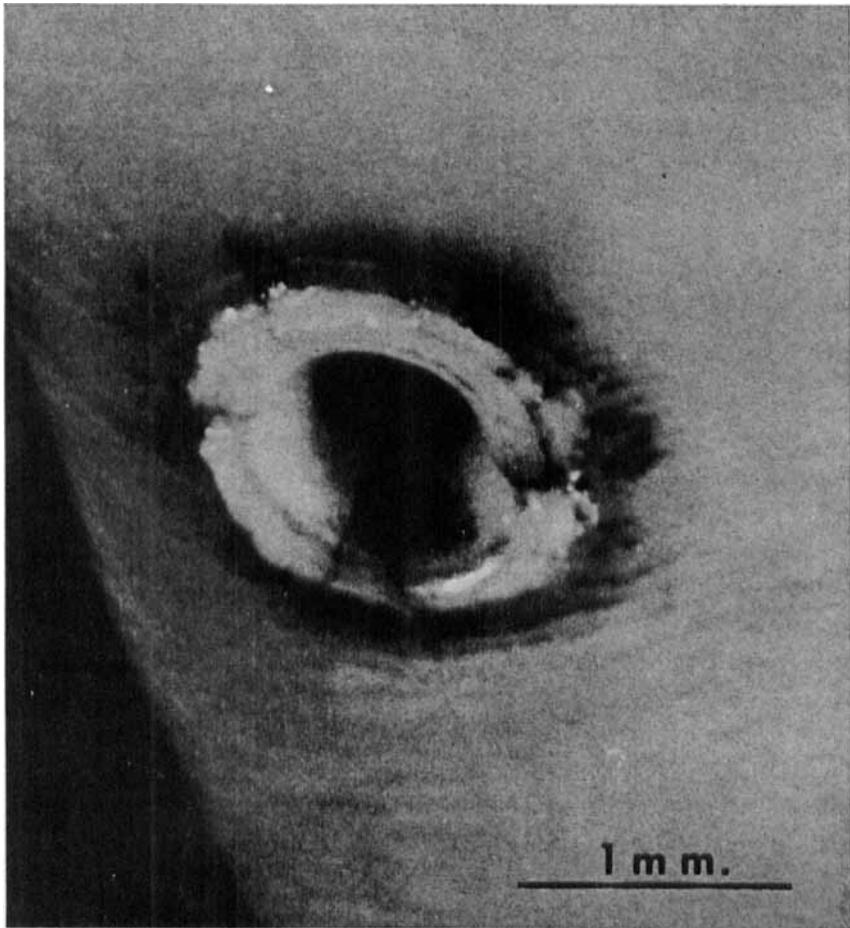


Fig. 1. Crater produced by application of focused infrared CO_2 -laser radiation for 1 second. Note the carbonized residue in the periphery of the crater and fracturing of the enamel.



Fig. 2. Crater produced as in Fig. 1. Compare the carbonization of surface (A) and subsurface (B) enamel.

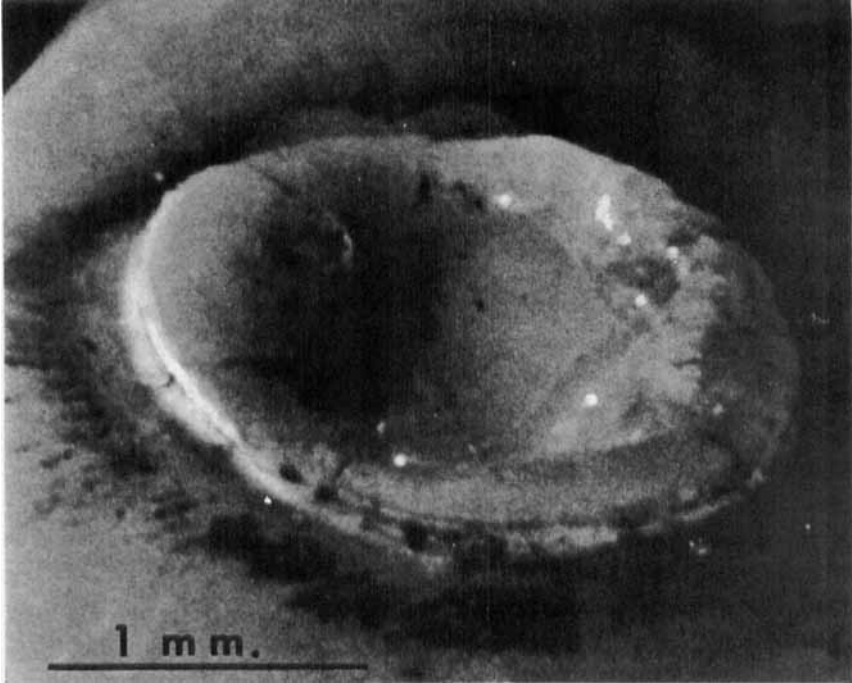


Fig. 3. Crater restricted to enamel only. Note the elevated rim at the margin of the lesion.

at the bottom of the perikymata (Figs. 1 and 2). Considerable cracking of the enamel occurred inside the crater, these ruptures radiating over a large part of the buccal surface of the tooth (Figs. 1 and 2).

The diameter of the craters varied between 0.5 and 2.0 mm. A one-second exposure resulted in craters restricted to enamel only. Extending the exposure to three seconds produced craters penetrating the enamel and reaching deep into the dentine. In the lower incisors, however, application for one second resulted in craters nearly penetrating the whole thickness of the tooth.

The borders of the craters formed an elevated rim (Fig. 3) which was clearly noticeable when examining the formation from a lateral aspect (Fig. 4).

DISCUSSION

In contrast to all previous studies, the present experiments were carried out by using a continuously operating gas laser for crater production in teeth. The main reason for selecting the equipment was the obvious effect of the

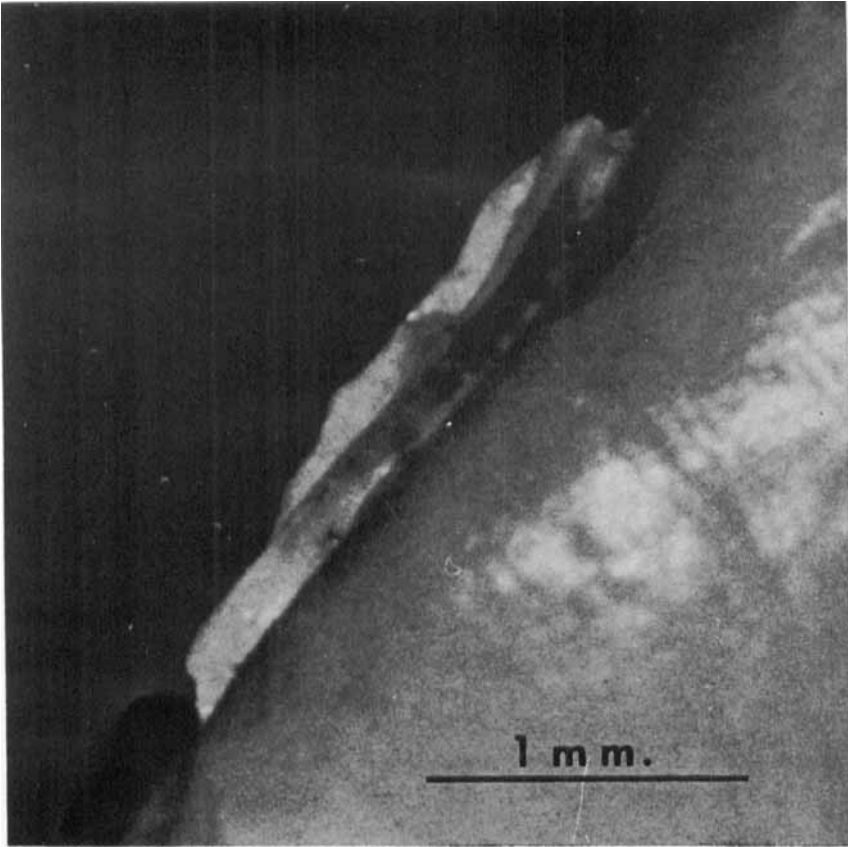


Fig. 4. Lateral view of crater seen in Fig. 3. Note the elevated rim.

CO₂-laser on the dental hard tissues. By these means, well-defined and substantial tissue reactions might be studied in order to ascertain the laser-induced effects, not yet fully understood.

Already a macroscopic examination of the craters produced in the present series of experiments revealed that the energy density of the focused laser beam was high enough to melt and vaporize the hydroxyapatite of the enamel. At the borders of the craters, part of the melted and vaporized structure was recondensated. Evidence of the fusing was the formation of elevated rims of the craters (Figs. 3 and 4).

The organic constituents of the enamel were combusted to varying extent. The most complete combustion was found at the surface of the craters, as

indicated by their whitish color. Incomplete carbonization, on the other hand, was manifested by the burnt residue at the periphery of the lesions (Figs. 1—3).

The fracturing of the enamel was considered to be created by the rapid expansion of water and/or enamel fluid due to the high energy density of the laser beam.

The laser-induced changes in the microstructure of the tooth will be reported in a separate paper.

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SUMMARY

Exposure for 1 to 3 seconds to an infrared laser beam, focused by germanium optics, resulted in marked crater formation penetrating the whole thickness of dental enamel. The borders of the cavities thus created were elevated due to condensed material from melted and vaporized dental enamel. The organic constituents of the enamel were combusted to varying extent, carbonized residue being observed especially in the periphery of the craters. Several fissures, radiating from the site of exposure, regularly originated from the laser beam impact.

RÉSUMÉ

EFFETS PRODUITS PAR LES LASERS SUR LES TISSUS DENTAIRES. I. PRODUCTION DE CRATÈRES À L'AIDE D'UN LASER À CO₂

Une exposition de 1 à 3 secondes aux rayons infrarouges d'un laser, condensés par optique de germanium, a résulté dans la formation de cratères pénétrant toute l'épaisseur de l'émail dentaire. Les bords des cavités ainsi formées étaient surélevés, à cause de la condensation de produits résultant de la fonte et de la vaporisation de l'émail dentaire. La combustion des constituants organiques de l'émail atteignait des degrés divers: un résidu carbonisé s'observait surtout à la périphérie des cratères. L'action du laser provoquait régulièrement plusieurs fissures, rayonnant à partir de l'endroit frappé par le faisceau du laser.

ZUSAMMENFASSUNG

EINWIRKUNGEN DER LASER-BESTRAHLUNG AUF DIE ZAHNSTRUKTUR.

I. HERVORRUFEN DER KRATER DURCH CO₂-LASER

Durch einen von 1 bis 3 Sek. dauernden, mit Germaniumoptik fokussierten infraroten Strahl wurde eine deutliche Kraterbildung hervorgerufen, die den Schmelz in seiner gesamten Dicke durchdrang. Das von dem geschmolzenen und gedampften Schmelz entstandene kondensierte Material verursachte höher liegende Ränder an den laserbedingten Kratern.

Die organischen Stoffe des Schmelzes brannten in wechselndem Masse, verkohlte Reste wurden besonders in der Peripherie der Krater gefunden. Die Laser-Bestrahlung hatte regelmässig zahlreiche Fissure als Folge, die von dem Radiationspunkt strahlenförmig verliefen.

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