The Impact of Nd: YAG Laser on Permanent Teeth's Pulp, Dentin, and Enamel

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ABSTRACT

In order to learn more about how the Nd: YAG laser affects enamel ,dentin, and pulp, Scholarly , articles were acquired from three distinct sources.in those study , the three tissues or a portion of them were exposed to the Nd:YAG radiation .beam of YAG laser, largely in vitro, and the results were later seen. The hardness and acid resistance The hardness and acid resistace of enamel increased, making the laser a realistic choice to offer some defense against tooth cavities.

Moreover, the roughness increased. Some laser settings produced a surface that looked like glass. Surface alterations resembling acid etching were achieved by various lasing settings. Dentinal tubules were blocked and its permeability decreased. This could account for the decrease in dentin hypersensitivity following lasing. Both enamel and dentin developed cracks and microfissures as a result of prolonged exposure and increased beam energy. A study revealed that although the laser has been used to remove the smear layer from dentin, it may not be efficient. The pulp got pain relief brought on by laser. The laser demonstrated that it can enhance pulp local blood flow.

Keywords: Nd:YAG laser , enamel ,dentin, and pulp, Scholarly

Introduction:

Light Amplification by Stimulated Emission of Radia tions referred to as LASER. Devices based on this id ea use a medium to create a coherent beam of light with a single wavelength. A heat source or a light so urce pumps energy into the lasing material.

This theory enables the rapid transmission of l arge amounts of energy to a small region over a short period of time, resulting in a localized in crease in temperature [1] .

The neodymiumdoped yttrium aluminum garn et (Nd:YAG) laser is one that has been put to use.[2] It is now regar ded as by far the most widely usedSolidstate la ser and has grown significantly in relevance in a variety of sectors, including medicine. [3] It h as been utilized in a variety of medical specialti es, including surgery, neurology, and ophthalm ology. [4] The purpose of this study is to collect factual information about the effects of the Nd:YAG laser on dental ename l, dentin, and pulp, particularly in permanent t eeth, from published research documents.

Laser Nd:YAG

The neodymiumdoped yttrium aluminum garn et ($Nd:Y_3Al_5O_{12}$), which serves as the laser's l asing medium, is a solidstate laser.[5] It is ofte n optically pumped by an LED. The predominan t emission wavelength is 1064 nm.

Furthermore, emissions are present at 946, 112 0, 1320, and 1440 nm. [4] Due to the high therm al conductivity of Nd:YAG, it can shoot the beam continuously or in pulsed mode. [2] An optical c able is utilized to deliver the laser beam, and lenses are employed to concentr ate it.[6]

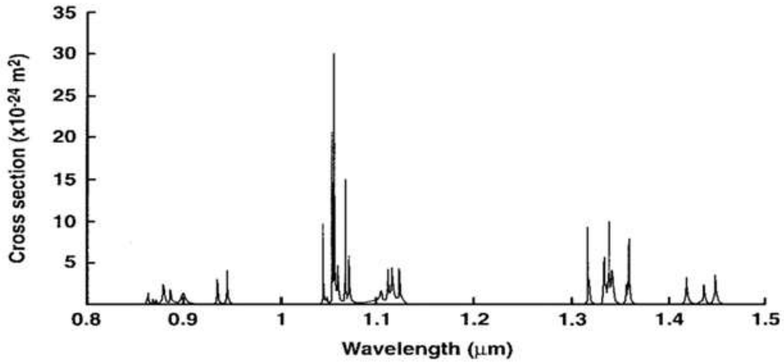

Figure 1 Fluorescence spectrum of Nd:YAG Laser(Adapted)[7]

Pulp, Dentin, and Enamel

Every tooth has an enamel crown, which is a w hite, translucent covering of calcified tissue.[8] It acts as a layer of protectio n. The cusp tip of a molar has enamel that is 2.5 mm thick, but the tooth cervix has enamel that is as thin as a knife**.**

The dentin, a partly calcified tissue with a thick ness of roughly 3 to10mm, is located deep with in the enamel. The pulp is a wellvascularized co nnective tissue that makes up the core. [9], [10]

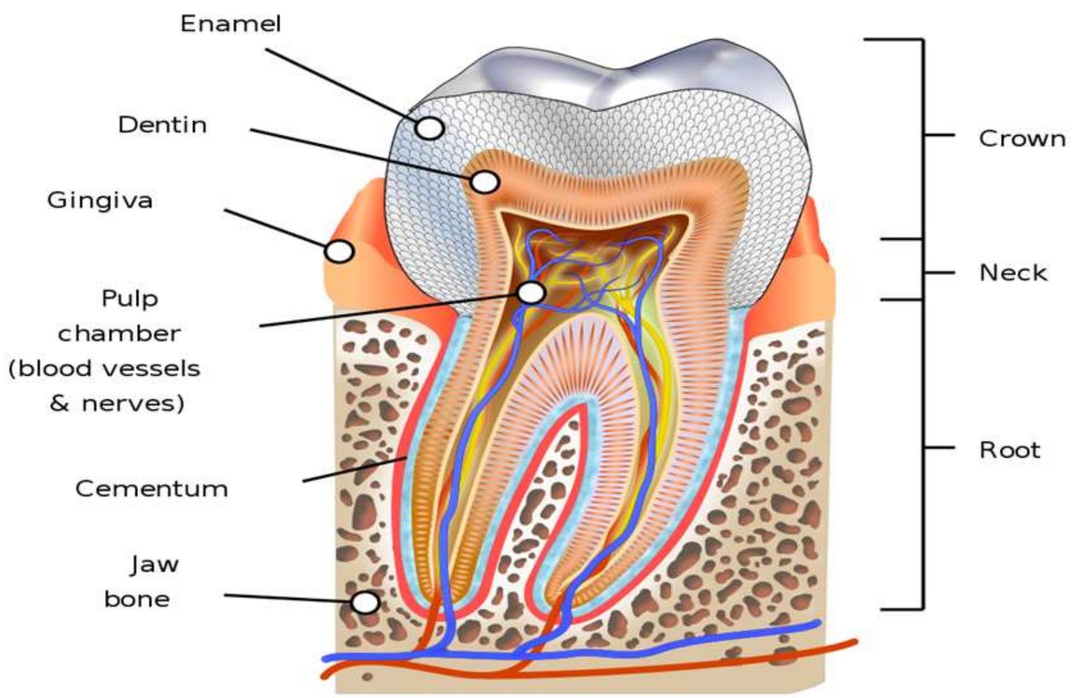

Figure 2 Diagram of a human molar[11]

Enamel

The enamel is brittle and considered the hardest calcified tissue in the body.[12], [13] It is non-vital and not sensitive. It is produced by specialized epithelial cells called the ameloblasts. It covers the coronal dentin and decreases in thickness towards the tooth cervix. It is translucent with a grayish or yellowish white color.[9] The enamel is composed mainly of hydroxyapatite crystals. These crystals are arranged in rods that follow a tortuous course from DEJ to the tooth surface and are key-hole shaped in cross-section.[14], [15] The head of the key-hole shape and the tail are called the rod head and the interprismatic substance, respectively. The width of each rod varies along its length with an average of 4µm. There is a small space between the rods occupied by an organic matrix called the rod sheath.[9]Chemically, enamel is composed of 96% inorganic material with the remaining 4% being organic material and water. The inorganic material is the hydroxyapatite $Ca_{10}(PO_4)_6(OH_4)_2$.[16] During tooth development, magnesium and fluoride may be incorporated into the hydroxyapatite crystals and replace calcium and hydroxyl, respectively.[9] The organic component is made of proteins; amelogenins and non-amelogenins.[17] Also, enamel may contain iron, manganese, lead, fluoride and other elements in small amounts.[18]

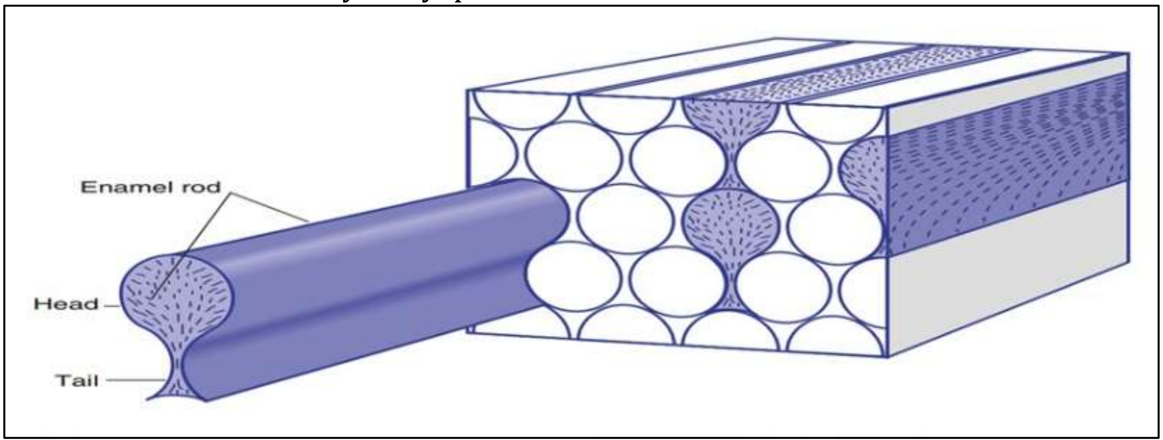

Figure 3 Diagram of enamel rods(adapted)[10]

Dentin

The tooth dentin is yellow in color, brighter in young individuals and gets darker with age. It is viscoelastic and can withstand a slight elastic deformation without fracturing. It consists of has inorganic matter (65%) and organic matter and water (35%).[9] The organic part is composed of collagen fibrils arranged in a network and embedded in a ground substance of mucopolysaccharides. The inorganic part is made of plate-shaped hydroxyapatite crystals that are much smaller than enamel hydroxyapatite crystals.[16]

Structurally, the dentin is penetrated by tubules that run at right angles from the pulp and end up perpendicular to the DEJ and CEJ making an S-shaped path in most of dentin. They are called the dentinal tubules, each one of them has a diameter of 1-4µm and they contain the cytoplasmic process of the odontoblasts, the cells responsible for forming the dentin.[19] Near the pulp, there are 50,000-90,000 dentinal tubules per square millimeter. Their diameter is smaller near the DEJ and gets larger towards the tooth pulp.[20] Each tubule has microtubules of less than 1µm diameter branching from it at right angles every 1-2µm of the tubule length.[21]

The material that forms the wall of each dentinal tubule is called the peritubular dentin and the material that forms the dentin between the tubules is called the intertubular dentin, is less mineralized and contains more organic matrix than peritubular dentin.[16] There are hypomineralized areas in the dentin called the interglobular dentin.[22] The dentinal fluid is present in the periodontoblastic space, between the odontoblast process and the peritubular dentin. Growth of dentin is continuous and there is an unmineralized layer of predentin around the pulp that has been recently secreted by the odontoblasts that will undergo mineralization to form a new layer of dentin.[9]

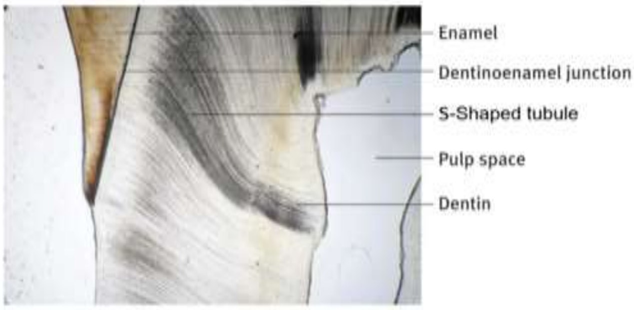

Figure 4 Photomicrograph showing enamel and dentin with dentinal tubules(adapted)[9]

Pulp

Peripherally, there are the odontoblasts, surrounding pulp and secreting the predentin. There is an area devoid of cells, termed the cell-free zone, found internal to the odontoblasts and provides space for their pulp-ward movement. Deep to the cell-free zone, there is the cell-rich zone which has fibroblasts, stem cells and defense cells. Internally, there are the main nerve trunks, lymph and blood vessels. The nerves extend peripherally and most of them terminate near the odontoblasts, but some extend into the dentinal tubules.[16], [19]The intercellular substance contains glycoproteins, proteoglycans and glycosaminoglycans. Also, collagen fibers are present in the pulp, mainly type I collagen. There is type III collagen as well.[9]

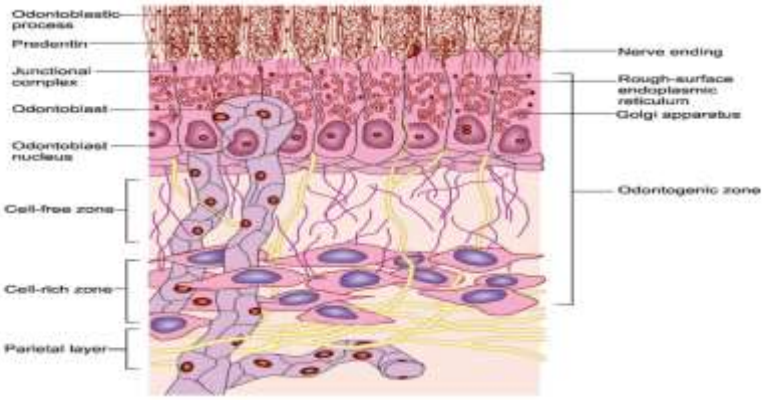

Figure 2 Diagram of pulp zones[9]

Results

Enamel

The laser showed its ability to significantly increase acid resistance and decrease demineralization.[26], [27] Structural water and carbonate can be reduced.[28] There were surface modifications including glass-like areas, increased roughness and areas similar to acid-etching, having honeycomb appearance.[29]–[31] With high exposure, cracks and fissures can form.[32] There was an increase in hardness as well, but the increase was not significant.[26], [31]

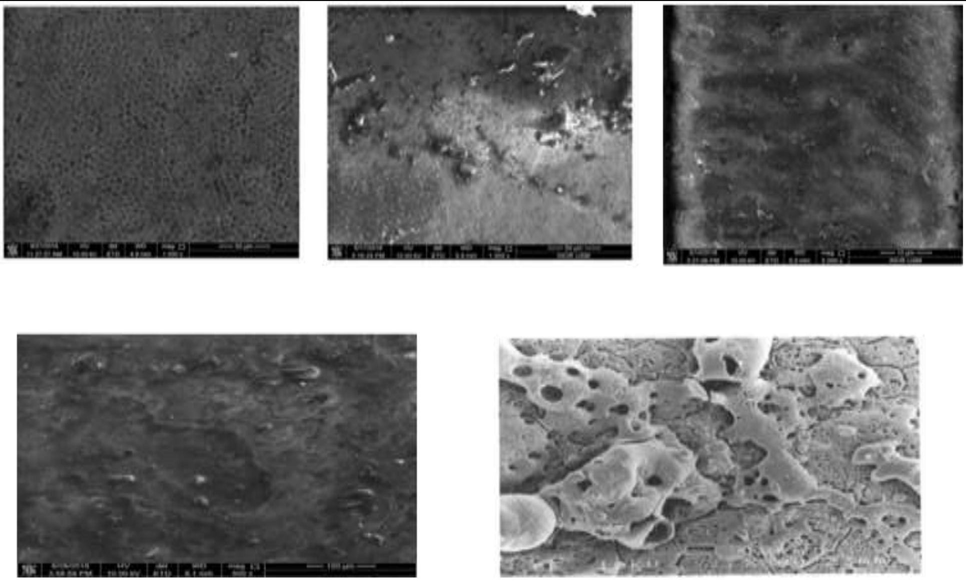

Figure 3(a) Surface morphology of a laser-etched sample with a fluence of 120 J/cm2 at 1000x magnification.(b) Surface morphology of a laser-etched sample with a fluence of 80 J/cm2 at 1000x magnification.(c) Surface morphology of an acid-etched sample at 500x.(e) Scanning electron microscopic appearance of laser-etched enamel at 20 Hz 1.25 W. Magnification, 800x.[30], [32]

Dentin

The laser can cause melting and recrystallization of the superficial layer of dentin, decrease permeability and effectively obstruct dentinal tubules.[33]–[38] The effects reduced dentin hypersensitivity for at least 6 months.[39] It can also cause a decrease in Ca/P ratio without changing the mean percentage of Ca, Mg, K, Na and P.[40] There was also a decrease in the hardness of dentin and its elasticity.[41]

A study employed scanning electron microscopy and showed that the irradiated dentin demonstrated a sponge-like surface with large cracks but no exposed dentinal tubules.[42] High exposure can cause those cracks to form.[43] The laser caused a decrease in root dentin permeability.[44]–[46] It may have no morphological or histological changes when used with certain lasing settings and can have no effects on the mineral content.[47], [48]

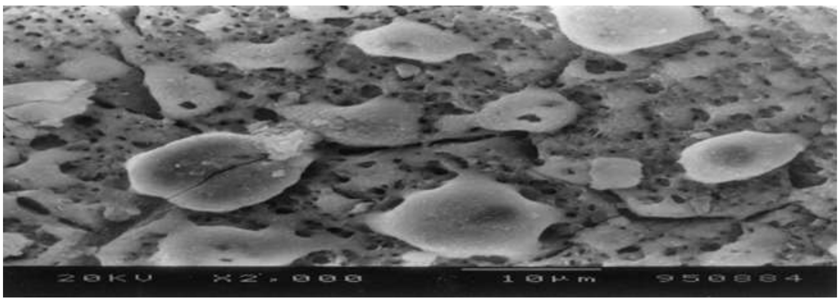

Figure 4 Photomicrograph of dentin surface after lasing with Nd:YAG laser showing an extensive sponge-like smear layer and some cracks in the surface (32000).*[42]*

Pulp

The laser can produce pulpal analgesia by suppressing intradental nerve response to electrical and mechanical stimuli.[49] An in vitro study showed that the laser did not cause any injuries to the fibroblasts and does not promote collagen synthesis.[50] It is highly likely that there will be no effects if there is 1mm dentin layer over the pulp.[51] The laser can improve local blood flow without the need for directly irradiating the pulp.[52]

Discussion

The acid resistance obtained from irradiating enamel might be used as a preventive measure against dental caries provided that the beam energy is suitable and a photoabsorber is used.[26] Experimentation proved that laser-etching up to 1.2W with 20Hz wasn't as good for bonding dental composite restorative materials as the conventional acid etching technique even with a laser-enhancing gel.[32] As for the dentin, the laser with 1W, 15Hz can be used to reduce dentin hypersensitivity for at least half a year.[39] Although, the Nd:YAG laser shows promising results in some cases, it alone might not be the best option for this type of treatment.[39], [53]–[55] Parameters of 1.25W and 20Hz should be avoided as they produce microcracks in enamel and dentin.[32], [43] The Nd:YAG laser, even though it promotes partial removal of debris, a study showed that the smear layer and debris are removable but a different study claimed it wasn't effective in removing them.[56]–[58] In a case study, the laser was employed in pulp capping without postoperative complications.[59] Parameters of 1.1W ,15Hz, 150µs pulse and 240s produced pulpal analgesia without significant tissue destruction.[49] Further research is required to study the pulpal effects of the laser.

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