

Effects of 810nm Diode Laser Irradiation on Flexural Strength of Dentin: An Invitro Study

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Abstract:

Introduction: Thermal changes in laser assisted root canal therapy with the use of diode laser can predispose tooth structure to the fracture. This study evaluated the changes in flexural strength of dentin blocks after diode laser irradiations (810 nm).

Methods: A total of 60 dentinal blocks were prepared from freshly extracted teeth in three different thicknesses (300, 500 and 1000 μ m) and 20 sections in each of these thicknesses were divided randomly to the test and control groups. Samples in the test groups were irradiated at 2W power setting by scanning movement of 2mm/s of diode laser, and the controls were stored in normal saline. The flexural strength of samples was evaluated by UTM (Universal Testing Machine). Data analysis was done with the SPSS Software 11.5.

Results: Samples of 300 μ had the lowest flexural strength (mean: 71/65 mpa) followed by 500 (116.64 mpa) and 1000 μ (217.56 mpa). Statistical analyses showed that after laser irradiation, the flexural strength in the samples of 300 μ was significantly lower than that in the other groups (500 μ , 1000 μ) (P= 0.017).

Conclusion: Within the limits of this study, diode laser irradiation in laser assisted root canal therapy has no significant effect on flexural strength of root dentinal walls with the thickness of more than 500 μ . Although in areas with critical dentinal width (\leq 300 μ), this setting can jeopardize root micromechanical properties and predispose tooth to the root fracture.

Keywords: diode laser; strength; dentin

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Introduction

Bacterial contamination of the root canal system is considered the principal etiologic factor for the development of pulpal and peri-apical lesions (1,2). Obtaining a root canal system free of irritants is a major goal of root canal therapy. Biomechanical instrumentation of the root canal system has been

suggested to achieve this task. However, because of the complexity of the root canal system, it has been shown that the complete elimination of debris and achievement of a sterile root canal system is very difficult (3,4), and a smear layer containing bacteria, covering the instrumented walls of the root canal, is formed (5,6). It contains inorganic and organic substances including microorganisms

and necrotic debris (7).

Because most currently used intra-canal medicaments have a limited anti-bacterial spectrum and a limited ability to diffuse into the dentinal tubules, it has been suggested that newer treatment strategies designed to eliminate microorganisms from the root canal system should be considered. These must include agents that can penetrate the dentinal tubules and destroy the microorganisms, located in areas beyond the host defense mechanisms, where they cannot be reached by locally administered antibacterial agents (8).

Numerous studies have documented that Carbon Dioxide Laser (CO₂), Neodymium-Doped Yttrium Aluminium Garnet(Nd: YAG), (9) argon, Erbium, Chromium doped Yttrium Garnet (Er,Cr:YAG), and Er:YAG laser irradiation has the ability to remove debris and smear layer from the root canal walls following biomechanical instrumentation.

The Nd: YAG and the diode laser wave length are not absorbed in the hard dental substances, and are thus able to be effective in the deep layers (10). So, these properties of laser light may allow a bactericidal effect beyond 1mm of dentin. However, there are several limitations that may be associated with the intra-canal use of lasers that cannot be overlooked.

Up to now, numerous studies have shown different clinical aspects of diode laser application, such as the temperature of the root surface after irradiation, but there are few studies about changing in biomechanical characteristics of root dentin (11).

So, the purpose of this study is to evaluate the effect of 810 nm diode laser irradiation on bending strength of dentin.

Methods

Freshly extracted human molars teeth with no caries, or restoration in the cervical portion of the teeth were selected. Then, 60 dentinal blocks were prepared in 3 mm ×3 mm, but in three different thicknesses (300, 500 and 1000µm) with Isomet device (Buehler Germany) (Figure 1,2). Dentinal blocks were always kept wet.

20 sections in each of the thicknesses were divided randomly into the test and control groups.

The samples in the test group were irradiated at 2W power setting by scanning movement of 2 mm/s of diode laser (810 nm) with a 200 micron-

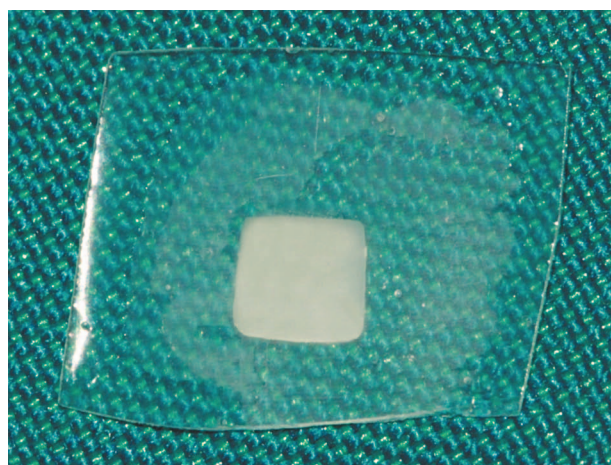


Figure 1. Dentinal block sample (300µm)



Figure 2. Isomet device

optical fiber in continuous wave mode (Figure 3).

Irradiation was performed with a 15°- angle on dentinal blocks (Figure 4), and the controls were stored in normal saline without irradiation.

Then, the flexural strength of samples was evaluated by Universal Testing Machine (speed:



Figure 3. Diode laser 810 nm

0.5mm/min, distance of fulcrum: 2.5mm) (STM20, Santam, Tehran, Iran) (Figures 5,6).

Bending strength of the samples was calculated



Figure 4. Fixation of laser in putty with angle of 15°

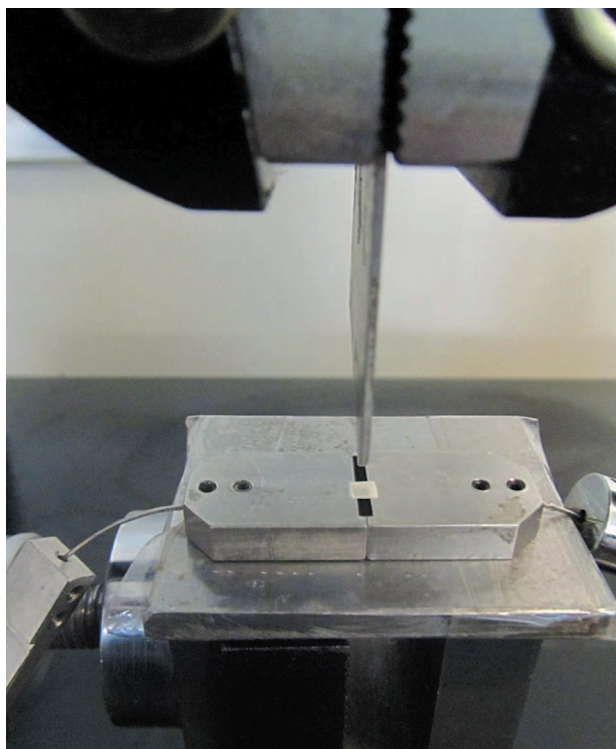


Figure 5. Universal testing machine (UTM)



Figure 6. Universal testing machine (UTM)

with $\delta = \frac{3PI}{2bd^2}$ formula. Data analysis was done with SPSS version 11.5 and ANOVA and T-Test.

Result

Samples of 300µ had the lowest flexural strength (mean: 71/65±24.77 mpa) followed by 500 (116.64±48.87 mpa) and 1000µ (217.56±58.16 mpa).

Statistical analysis showed that after laser irradiation, the flextural strength in the samples of 300µ was significantly lower than other groups (500µ, 1000µ) (P= 0.017).(Table 1, Figure 7)

Discussion

In this study, we used dentin chips of extracted human teeth. Dentin chips with 300, 500, and 1000 µm thickness provided us with the possibility of assessing the probable effects of 810 nm diode laser (used for the sterilization of dental canal) on the flexural strength of dentin. It is necessary

Table 1. The average of flexural strength in control and experimental groups

Thickness (µm)	Groups		Pvalue
	Without laser irradiation	With laser irradiation	
300	98.22 ± 20.26	71.65 ± 24.77	0.017
500	131.32 ± 39.97	116.46 ± 48.87	0.466
1000	225.53 ± 60.43	217.56 ± 58.16	0.555

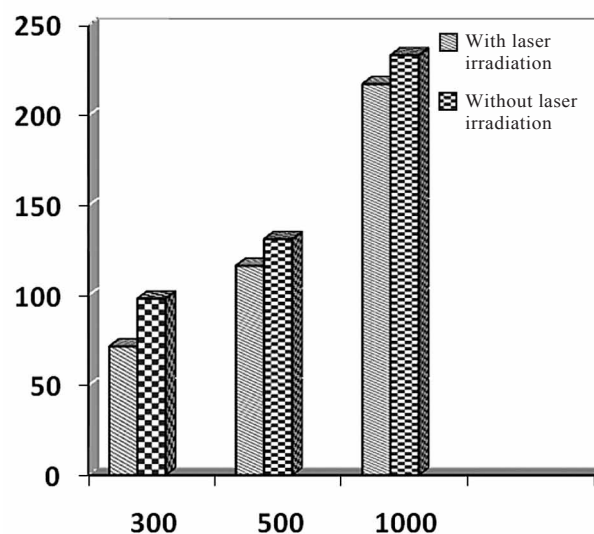


Figure 7. The average of flexural strength in control and experimental groups

to mention that the thickness of critical dentin is considered 0.3 mm, which is mostly observed in the danger zone of root furcation (12).

A diode laser can eliminate the bacteria from root canal system with a thermal effect beyond 500µm dentin. This effect is directly related to the amount of irradiation and to its energy level (13). This thermal effect regardless of its antimicrobial effect can modify the remainder dentin structure. These changes can explain the significant difference in flexural strength in 300 µm thick dentin in the study samples.

Of course, lack of significant difference in 500 and 1000 µm thicknesses shows that possible structural changes after this irradiation pattern were limited to the surface of dentin and in clinical conditions it doesn't cause a negative effect on the resistance of root dentin fracture.

Kreisler et al in 2002 studied the thermal effect of 810 nm diode laser on dentin and used a diode laser with a 2.5 W power, by a 400 micron optical fiber. They showed that laser irradiation through 1 mm thick dentin for 10, 20, and 30 seconds caused 24°C, 27°C, and 29°C temperature rise, respectively (14).

This temperature rise is decreased when using 2 W power (like this study), but inside the canal where laser radiation directly affects the tissue, this temperature rise is much higher than aforementioned ones. In order to reduce this thermal effect in clinical conditions, laser is irradiated parallel to the longitudinal axis of tooth with an angle of approximately 15°. This irradiation pattern and continuous movement of fiber on the dentin prevents temperature rise and minimizes the side effects of this setting.

Kreisler et al (15) investigated the structural changes of dentin after laser irradiation. In Kreisler's study, 200 micron optical fiber was used like our study. And the considerable point which can explain the reduced flexural strength in the 300 µm thick samples is dentin melting and limited areas of destruction in canal wall in SEM observation of some samples in this study which was consistent with ours.

In spite of our knowledge about thermal effect of diode laser on dentin and reduced strength of 300 µm thick samples, explanation of this effect and anticipation of possible changes in dentin structure seems difficult. Some studies may help

us for explaining this effect.

Bachinger (16) showed that type I collagen in soft tissue was degenerated at 43-60° C, but mineralized collagen was destroyed approximately in 150° C (17). In another study, Bachman evaluated the changes in chemical composition and collagen structure of dentin tissue after Erbium laser irradiation. In Bachman's study, loss of water, alteration of the collagen structure and composition, and OH⁻ increase in superficial layer was observed (11). According to the aforementioned studies, the alteration of dentine structure can be the cause of decreased flexural strength after laser irradiation in 300µm thickness.

Loss of dentin water which comprises 25% of its volume can also explain the reduced flexural strength of 300-µm thick samples in this study. In thermal analysis, the first chemical composition which is affected in the tissue is water. Studies have shown that free water in soft tissue will completely vaporize after heating to 200°C, but the water which is bonded to other tissue structures needs a temperature of 400 to 1200°C for complete evaporation (18,19). And de Costa Riberio found that the temperature rose to 29° C on the root surfaces after application of diode laser (2.5 W, 400 micron optical fiber) (20).

With this description, since only the superficial layer of dentin will experience a temperature near water evaporation, this process can just significantly reduce flexural strength in low thickness dentin.

It is worth mentioning that in the clinical and real conditions, the remainder dentin thicknesses of lower than 500 µm can't be normally observed. This may only be observed in some special anatomic zones, such as dentin over the danger zone of the root furcation or after undesirable filing. According to the results of this study, it can be recommended that when facing these situations, it is better to use alternative methods for sterilization of root canal or to use a lower output power of the device and a 400 micro-optical fiber, or to increase the speed of fiber movement in the canal to reduce the received dose of radiation and to minimize the possible side effects in the anatomical zones exposed to the dental tissue fracture.

Another important point in the explanation of the results of this study: in most methods of root canal sterilization, we may face some degrees of reduced resistance to fracture in the dental canal

walls. And studies(21-23) show that chemical disinfectants can also potentially lead to decreased strength and resistance of dentin to fracture in the zones with weakening structure. For example, Sim et al. showed that sodium hypochlorite 5.25% can decrease elastic modulus and bending strength of the dentin (24).

And as a final point, diode laser irradiation in laser assisted root canal therapy has no significant effect on flexural strength of root dentinal walls with the thickness of more than 500 μ . Although in areas with critical dentinal width ($\leq 300\mu$), this setting can jeopardize root micromechanical properties and predispose tooth to the root fracture.

Conclusion

Application of 810 nm diode laser is not recommended in the remainder critical dentin. Since laser affects superficial dentin without any effect on deep dentin, and its effect is almost equivalent to the effects of disinfectant solutions, it can be reasonably used for dental canal sterilization

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