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ORIGINAL RESEARCH

# Structural and Compositional Changes of Human Root Surfaces on Exposure to Diode Laser (810 nm): An *in vitro* Study

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**ABSTRACT**

*Introduction:* The adjunctive use of lasers in the treatment of inflammatory periodontal diseases is gaining popularity in the dental offices. Thermal and photo-disruptive laser effects contribute to the elimination of periodontal pathogens. Clinical studies have demonstrated a highly supportive effect of many laser systems, when used in conjunction with scaling and root planing. Several *in vitro* studies have, however, indicated that lasers may severely damage root surface structures and inhibit new cellular attachment when certain energy levels are exceeded. The present study focuses on the structural and compositional changes induced on the root surfaces of teeth following diode laser application with increasing quantum of exposure time.

*Aims and objectives:* To examine the structural and compositional changes on the roots of extracted human permanent teeth after application of diode lasers (810 nm).

To evaluate and compare structural and compositional changes on roots of extracted human permanent teeth after diode laser application for 15, 30, 45 and 60 seconds.

*Materials and methods:* A total of 20 single rooted extracted teeth were utilized for this study and divided into group 1: laser application for 15 seconds, group 2: laser application for 30 seconds, group 3: leser application for 45 seconds and group 4: laser application for 60 seconds.

Diode laser (810 nm) application was done in the noncontact mode. A scanning electron microscope (SEM) was used to examine the cemental surface and compositional changes of the teeth in each group were further assessed using EDAX software.

*Results:* As the exposure time of the diode laser (810 nm) on the root surface was increased, there was a concomitant increase in surface irregularities, manifested in the form of cracks and charring. There was also a decrease in the calcium and phosphorus mass percentage, as the time of laser application increased.

**Keywords:** Extracted teeth, Exposure time, Scanning electron microscopy (SEM), Cementum, Compositional changes, Ultrastructural changes.

## INTRODUCTION

Lasers have been widely used in medicine and surgery, since the development of the Ruby laser by TH Maiman in 1960. High power lasers designed for surgery, deliver concentrated, yet controllable energy to the tissue. For a laser to have a biological effect on the tissue substrate, the energy must be absorbed by the tissue. The degree of absorption in tissue will vary as a function of the wavelength of the laser and optical characteristics of the target tissue. If the peak emission of the laser matches the absorption spectrum of one or more components of the target tissue, a predictable and specific interactive effect will occur. Since all biological tissues have more than one component, the overall effect would hence be a combination of the effects on each tissue component.[1] Laser surgery hence offers significant and predictable advantages over conventional and traditional techniques.

### Advantages of Lasers over Conventional Surgery[2]

1. Dry and bloodless surgery
2. Instant sterilization of the site
3. Reduced bacteremia
4. Reduced mechanical trauma
5. Minimal postoperative swelling and scarring
6. Minimal postoperative pain.

### Rationale for Laser Therapy in Periodontics

It is widely accepted that periodontal diseases are opportunistic infections. Various subgingival microflora, like *Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis* etc. invade the soft tissue wall of the periodontal pockets. Furthermore, bacterial products, such as endotoxins, detected in the cemental wall of periodontal pockets prevent attachment of human gingival fibroblasts, soften the cemental surface (rendered

painful on probing) and constitute a possible reservoir for re-infection in post-treatment scenario. So, it becomes increasingly important to manage periodontal disease by addressing the microbes and thereby the patient's health.

The aim of periodontal treatment is to restore the biocompatibility of diseased root surfaces for subsequent attachment of periodontal tissues to the treated root surface.

This is achieved by:

1. Removal of local factors, necrotic cementum and endotoxins by scaling and root planing
2. Elimination of microorganisms from the soft tissue[3]

However, the disadvantages of conventional therapy are: [4]

1. Stressful for the patient
2. Discomfort (noise and vibration)
3. Complete removal of bacterial deposits and their toxins from the root surface and within periodontal pockets cannot be thoroughly achieved
4. Thorough access to grooves, concavities, furcations and distal areas of molars is limited
5. Formation of a smear layer and sometimes deep grooves on root surface.

Although systemic and local drug delivery of antibiotics can be administered for disinfection, it can still lead to the development of resistant microorganisms.[3]

The adjunctive use of lasers in the treatment of inflammatory periodontal diseases is gaining popularity in the dental practice.[5] Thermal and photo-disruptive effects of the diode laser cause the complete elimination of periodontal pathogens. Owing to the fact that lasers can penetrate those sites which conventional instrumentation cannot access, we can achieve excellent tissue ablation coupled with bactericidal and detoxification effects.

Diode (810 nm, 940 nm, 980 nm), Argon (488 nm, 514 nm) and Nd:YAG (1064 nm) lasers are well absorbed by melanin, hemoglobin and other bacterial chromophores present in diseased periodontal tissues.[8,9] The Erbium family lasers could also be used in treating periodontal infection.[6]

But one of the possible drawbacks of diode laser application, especially in the subgingival scenario, is the accidental contact of laser energy to the root surface which could lead to severe and irreparable damage to the root surface morphology and the pulp.[8,10]

Hence, a study was planned to examine the structural and compositional changes of roots of extracted human permanent teeth after application of diode laser (810 nm) and to evaluate and compare structural and compositional changes of roots of extracted human permanent teeth after diode laser application for 15, 30 , 45 and 60 seconds.

## MATERIALS AND METHODS

A total of 20 single rooted extracted teeth were utilized for this study.

They were divided into four groups:

- Group 1: Laser application for 15 seconds
- Group 2: Laser application for 30 seconds
- Group 3: Laser application for 45 seconds
- Group 4: Laser application for 60 seconds

Diode laser application (810 nm) was done in noncontact mode (approximately 1 mm from the root surface) at the power setting of 1 watt.

A scanning electron microscope (SEM) was used to examine the cemental surface and compositional changes of the roots of teeth in each group were assessed using EDAX software. The SEM analysis was performed by an independent examiner to avoid bias.

## RESULTS

### Structural Changes

1. *Group 1* showed debris and minimal surface irregularities in the form of cracks (Fig. 1)
2. *Group 2* showed debris and few surface irregularities in the form of cracks which when compared to group 1 was found to be significant (Fig. 2)

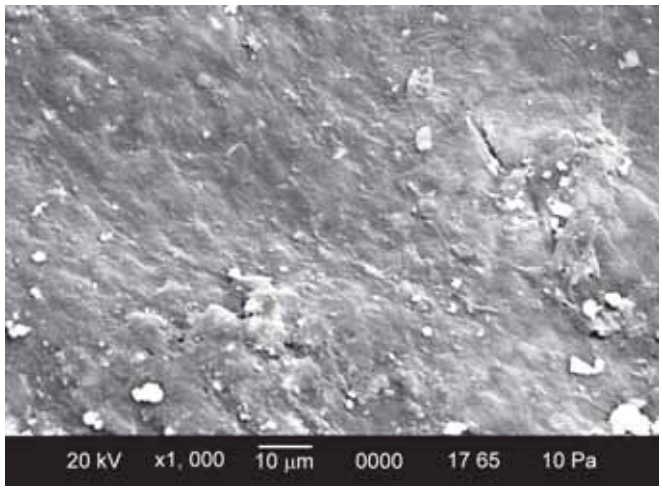


**Fig. 1:** Diode laser exposure for 15 seconds

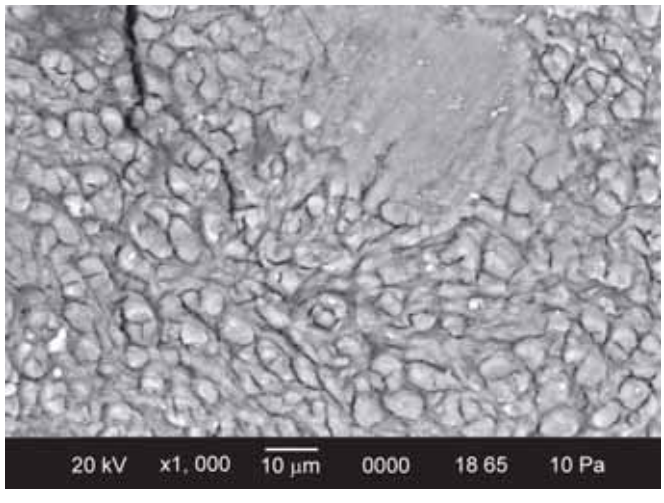


**Fig. 2:** Diode laser exposure for 30 seconds

3. *Group 3* showed debris and surface irregularities in the form of extensive cracks as compared to group 1 and 2 (Fig. 3)
4. *Group 4* showed debris with focal areas of surface irregularities in the form of extensive cracks and peelings and charring of the root surface (Fig. 4).

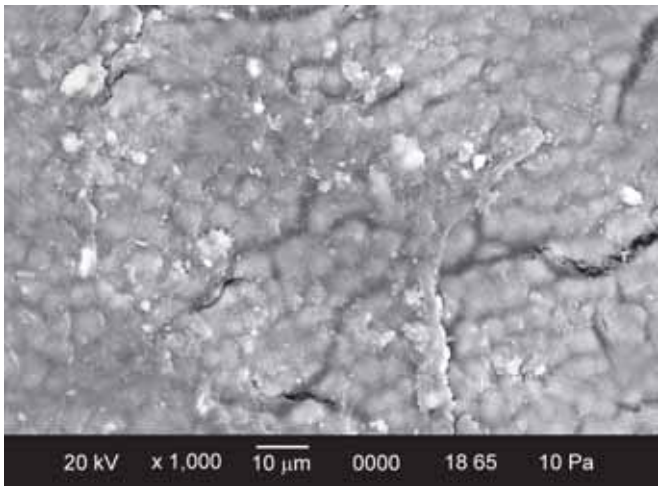


**Fig. 3:** Diode laser exposure for 45 seconds

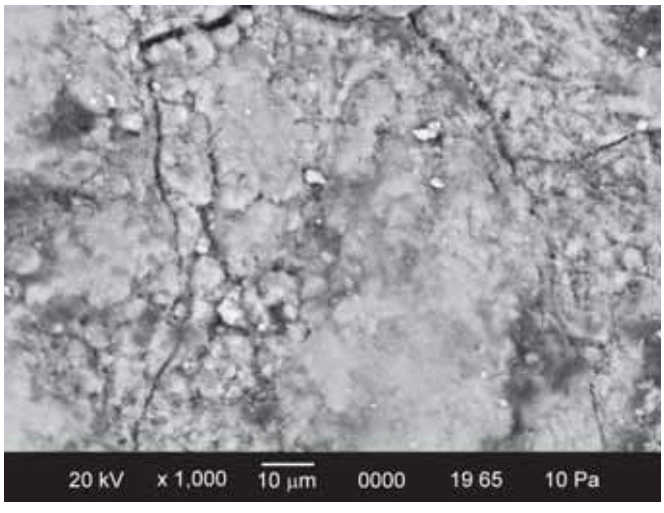


**Fig. 4:** Diode laser exposure for 60 seconds

## Compositional Changes

This study reveals a significant amount of compositional changes in the cementum as the exposure time of laser application increased, indicated by an increase in the amount of carbon. Notably a reduction in calcium and phosphorus is also observed as the exposure time of laser application increased (Table 1). The reason could be attributed to the charring and peeling which occurred during the laser application.

**Table 1:** Compositional changes

| *Mass (%)* | *Carbon* | *Oxygen* | *Phosphorus* | *Calcium* |
|---|---|---|---|---|
| Laser 1 | 27.09 | 46.93 | 10.70 | 16.36 |
| Laser 2 | 31.69 | 36.48 | 10.56 | 15.27 |
| Laser 3 | 46.39 | 40.42 | 4.94 | 8.25 |
| Laser 4 | 54.39 | 41.39 | 3.22 | 5.91 |

## DISCUSSION

Periodontal disease is multifactorial and caused by a number of subgingival microflora which colonize the periodontal pocket and invade the soft tissue wall of the periodontium. The root surface wall of periodontal pockets often undergoes changes that may perpetuate the periodontal infection, cause pain and complicate periodontal treatment.

The pathogenesis of periodontal disease and the methods of treating it have undergone radical changes for past 30 to 40 years.

Nonsurgical periodontal therapy includes:[7]

- Debridement of the tooth structure
- Local delivery of antimicrobials
- Host modulators
- Reduction of sulcular bacteria coupled with coagulation and selective ablation of diseased epithelium of the treatment site using lasers.

The aim of periodontal treatment is to restore the biocompatibility of root surfaces affected by disease and to provide for subsequent attachment of periodontal tissues to the treated root surface. Complete access and disinfection through conventional mechanical instruments may not be achieved during the treatment of periodontal pockets. The effectiveness of instrumentation may vary with the skills and experience of the practitioner and is therefore technique sensitive. Systemic and local drug delivery systems are important adjunctive tools to conventional mechanical therapy but they lead to the development of resistant microorganisms.[3]

To overcome these drawbacks, lasers have been introduced as an adjunctive tool for mechanical therapy.[3] Laser therapy is proving to be one of the most promising treatment modality in subgingival microbial reduction.[10]

Lasers have potential advantages of bactericidal effect, detoxification effect and the removal of the epithelium lining and granulation tissue which are desirable properties for the treatment of periodontal pockets. Some Lasers may be capable of effectively removing not only dental plaque but also calculus from the root surface with extremely low mechanical stress and no formation of a smear layer on the treated root surface. Furthermore, potential biostimulation effects by the scattering and penetrating laser energy on the cells surrounding the target tissue during irradiation might be helpful for the reduction of inflammation and healing of periodontal tissues.[3]

The purpose of this study was to assess the structural and the morphological effects on root surfaces treated with diode lasers at different exposure time intervals and it was found that as the exposure time of application of diode laser increases the damage to the root surface in the form of cracks and charring increases.

These findings correlate and concur with the studies done by Schwarz et al in 2001[11] and Morlock et al in 1992,[12] which said that when laser energy is applied directly to the root surface there was severe damage, which included cracks and grooves

which could be due to the dehydration of the root surface caused by the heat generated by the laser.

A study done by Kreisler in 2002 found that application of diode lasers causes damage to the periodontal hard tissues, if irradiation parameters are not proper.[13]

Furthermore, the studies done by Trylovich et al (2000),[14] Spencer et al (1992),[15] Thomas et al (2000),[16] Tewfik et al (1994),[17] Ito et al (1993)[18] led the American Academy of Periodontology to conclude that neither diode lasers nor Nd:YAG is an alternative to root planing. It can be an adjunct rather than replacement.

This study reveals a significant amount of compositional changes in cementum as denoted by the increase in the amount of carbon and a corresponding reduction in calcium and phosphorus as the exposure time of laser application increased. The reason could be attributed to the charring which occurred during the laser application.

## CONCLUSION

Many studies have proven that diode lasers can effectively remove microorganisms from the soft tissue wall of the periodontal pockets. Employing proper parameters and methods is a significant factor in the use of lasers to prevent accidental or excessive exposure which may cause irreversible and potential damage. In the present study, we found that as the exposure time of application of the diode laser on the root surface was increased, there was a corresponding increase in the surface irregularities on the root surface in the form of cracks and charring.

It can thus be concluded that diode lasers are safe and effective instruments in nonsurgical periodontal treatment as long as the laser energy is not directed onto the root surface. Prime importance in periodontal therapy should be given to removal of local factors and then diode lasers can be used as an adjunct to remove the microorganisms from the soft tissue wall.

## ACKNOWLEDGMENTS

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2. Diode lasers (810 nm) of AMD lasers used.

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