Semiconductor Diode Laser in Disinfection of the Root Canal System in Endodontics

Mithra N Hegde¹, Raksha Bhat², Preethesh Shetty³

¹Senior professor and Head of the Department, ²Senior Lecturer, ³Post-graduate student, Department of Conservative dentistry and Endodontics, A. B. Shetty memorial institute of dental sciences, Deralakatte, Mangalore-575018, Karnataka, India

Corresponding Author:
E-mail: rkshabhat@gmail.com

Abstract
Objective: The purpose of this study was to evaluate the efficacy of three different newer irrigation delivery techniques; namely endovac system, stropko irrigator and lasers with 2% chlorhexidine.

Methods: Forty teeth after disinfection by OSHA regulations were instrumented and inoculated with bacterial strains of E. faecalis. The teeth were divided into four groups and the irrigants were delivered with the Endovac, stropko irrigator and laser irradiation. One group served as the control and received no irrigation. The samples were incubated in Muller Hilton media plates and incubated for 24 hours. The colony forming units were determined and statistically analysed using the chi square test.

Results & Conclusion: According to the results obtained, laser group resulted in significantly higher antimicrobial effects compared with the endovac and stropko irrigation groups when in conjunction with chlorhexidine.

Keywords: Disinfection, Endovac, Irrigation, Lasers, Stropko Irrigator

Introduction
The most important objective during root canal instrumentation is the removal of vital and necrotic pulp tissue, infected dentin and dentin debris in order to eliminate most of the microorganisms from the root canal system (European society of Endodontontology 1994, American association of Endodontists 1998). Despite the advent of novel instruments and techniques, the design and the physical limitations of the endodontic instruments lead to hapless cleaning of the root canal system.¹,² The annihilation of persisting bacteria in the distant areas of the tubular root canal system is a major dispute in treatment regimen, and is essential for the long term conservation of endodontically treated teeth.³ E. faecalis is a non fastidious, therapy resistant, gram positive facultative anaerobe that can efficiently intrude onto the dentinal tubules, endurechemomechanical instrumentation and intracanal medication, conform to modified nutrient supply and proceed to remain viable within the dentinal tubules.¹ Therefore, irrigation is a crucial part of root canal debridement because it permits for cleaning beyond what may be achieved by root canal instrumentation. Endeavours have continuously been made to develop efficientirrigant delivery and agitation systems for root canal irrigation.

The EndoVac is a negative pressure irrigation system which has been reported to have the ability to prevent extrusion of the irrigation solution as well as clean the entire root canal system.⁶ The Stropko Irrigator system is used for precise control of air and/or water in any dental procedure (crown, bridge, restorative, endodontic, periodontic, surgical, implant, etc.) that requires irrigation or drying during the process. It is known for efficient cleaning and drying, eliminating splashing, regulated gentle air pressure and providing an accurate fine stream of water.⁷ The use of lasers like high power diode laser and neodymium-doped yttrium aluminium garnet (Nd:YAG) in endodontics has proved to be an innovative approach for disinfection, providing access to formerly unreachable parts of the tubular network, due to their ability to penetrate dental tissues better than irrigant solutions.⁷,⁸,⁹

Combination therapy using various medicaments or irrigation solutions together or in succession has been reported to be more effective for canal disinfection.¹ The purpose of this study is to evaluate the efficacy of three different irrigation delivery systems; namely; Endovac, Stropko irrigator and lasers in combination with 2% chlorhexidine in disinfection of the root canal system in endodontics.

Material and Methods
Forty non carious mandibular premolar teeth extracted for orthodontic purpose, were selected for the study. The presence of a single canal was determined radiographically with digital radiographs taken at different angulations. The teeth with open apices and fractured roots were excluded from the study. The teeth were disinfected according to OSHA regulations.¹⁰ Crowns of the teeth were transversally removed with high speed diamond disc. Working length was determined with the help of digital radiograph and prepared by serial preparation to a #30 K file, with
Saline as an irrigant; for easier inoculation of bacteria. Two coats of nail varnish was applied to seal the apex. The canals were dried with paper points and sterilization was achieved by gamma irradiation. The teeth were inoculated with bacterial strains of *E. faecalis* (ATCC 29212) and the teeth were incubated for 24 hours. A suspension of 50 μL of *E. faecalis* strand was incubated in 5 mL of brain heart infusion broth culture medium in 37°C incubator for 24 hours. The concentration of inoculation was then adjusted for a degree of turbidity according to McFarland scale which corresponds to bacterial concentration of 3×10^8 cells/ml, and corresponding to optic density of 550 nm. The root canals were filled with inoculation and were incubated for 21 days at 37°C in an incubator. All samples had a portion of inoculation transferred in 5% sheep blood Trypticase Soy Agar (TSA) plates to check *E. faecalis* bacterial growth at several time periods, with a result of 100% positive.[8] After incubation, the contaminated roots were randomly divided into 6 groups (n = 10) according to the disinfection regimen used.

Teeth were randomly divided into 4 groups; all 40 samples were inoculated with *E. faecalis* for 24 hours at 37°C and all the steps were conducted under sterile conditions. The first group; of 10 samples served as the control group; the second, third and the fourth group; the experimental group each containing 10 samples each.

**Group I:** (n=10)
This group comprised of the teeth which were cleaned and shaped, inoculated with strains of *E. faecalis* but no irrigation was done. This group served as the control group.

**Group II:** (n=10)
The teeth which were irrigated with the endovac irrigation system. Macroirrigation was performed with 2% chlorhexidine while the macrocannula was constantly moved up and down from its point of apical restriction to just below the canal orifice. This step was accomplished in 30 seconds. CHX was then left in the canal untouched for 60 seconds. This was followed by three cycles of microirrigation of 30 seconds each while the microcannula was moved up and down the full working length.

**Group III:** (n=10)
The teeth were irrigated with the stropko irrigator system. Irrigation was performed after attaching the stropko irrigator to the air/water syringe. The canal was flooded with 2% CHX and it was activated with the help of an endoactivator which is known to produce a tsunami effect causing flushing action in the canal. The canal is then reflooded with CHX and then the fluid is evacuated. Air pressure to air/water syringe must be properly regulated, it is usually it is 30-50 lbs. For air-drying in endodontic canals it must be reduced to 1-3 lbs.

**Group IV:** (n=10)
This teeth were irrigated with the laser system. After 2% CHX was deposited using a 30 gauge syringe, intracanal irradiation was performed using a high power 908 nm diode laser (Kavo Gentle Ray) with a 200 μm fiberoptic tip and set at a power of 2.5 W. Using an oscillatory technique, the diode fiber (200μm fiberoptic tip) was introduced 1 mm short of the apex and recessed in helicoidal movements at a speed of approximately 1 mm/sec, and repeated 4 times at intervals of 10 seconds between each one.

After irrigation, paper points were used to collect the samples from the teeth and were placed in brain heart infusion broth in microtubes and incubated for 24 hours. The samples in the microtubes were transferred to the petri dishes containing Muller Hilton diffusion media using a nichrome wire loop and incubated for 24 hours. The results obtained was statistically analysed using the chi square test.

**Results**
The mean CFU for all groups were: Group 1 = 10^8 per ml, Group 2 = 10^7 per ml, Group 3 =10^5 per ml, Group 4 = 0. Statistical analysis demonstrated statistically significant differences between the laser irradiated group (Group 4) and the endovac and stropkogroup (Group 2,3) and control group (*P <0.001*).
Fig 1: The following bar diagram depicts the colony forming units of bacteria observed when using different irrigation techniques.

The degree of disinfection for experimental groups, in relation to Group 1-control, which presented total contamination; Group 4 demonstrated 100% disinfection, Group 2 and Group 3 demonstrated 50% and 20% disinfection respectively.

Discussion

The primary etiological factors in the development of pulp and periapical lesions have been long recognised as microorganisms. In the present study, 2% CHX solution was used as an irrigant as it is known to have potent antimicrobial action and also have powerful substantivity. Root canal failure cases and persistent apical periodontitis have been commonly been associated with E faecalis (ATCC 29212). They also have the ability to reside inside the canals without the support of other micro-organisms and under specific conditions have the ability to infect the whole length of tubules within days. The effectiveness and safety of irrigation depends on the means of delivery; hence an increasing number of novel needle-tip designs and equipment are emerging in an effort to better address the challenges of irrigation. In the recent times lasers have shown great promise in the field of endodontics and studies have demonstrated the bactericidal effects of diode laser in root canal disinfection. Mortiz et al has reported that an 890 nm Diode laser was able to disinfect the root canal walls. However in the present study wherein a 980 nm Diode laser was used in conjunction with 2% CHX; the reduction in the colony forming units was found to be significantly reduced as compared to the control group. The results of the present study are in accordance with the studies done by Castelo et al, Thomas et al and Krishna Shetty et al which concluded that the diode used in conjunction with conventional chemo mechanical techniques demonstrated a significant elimination of E. faecalis in the root canals. The superior bactericidal effect of diode laser irradiation could be attributed to its greater depth of penetration (up to 1000 μm into dentinal tubules) when compared to the penetration power of chemical disinfectants, which is limited to 100 μm. It has been found that with progressive decrease in diameter of the deep dentinal tubules, the penetration of irrigants is restricted. Laser irradiation with its inherent properties of light scattering, local intensity enhancement and attenuation allows light penetration deeper in the dentin tubules contributing to a superior antimicrobial efficacy.

Diode laser spectrum (GaAlAs–Gallium Aluminum Arsenide) allows for greater absorption by water in dental tissues when compared with Nd:YAG laser. This results in greater laser light penetration through dentin with little interaction with it, making it possible to act on microorganisms present in the dentinal tubules. In addition, the diode laser causes a thermal photodisruptive action in the unreachable parts of dentin, resulting in an enhanced bactericidal effect in the root canal dentin.

According to the results of the present study; the Endovac irrigation system was
also found to be effective in eliminating the bacteria from the root canals but not as effective as the laser disinfection. EndoVac is known to pull the irrigant into the canal and remove it by negative pressure at the working length thus avoiding entrapment of air and also safely delivers irrigant until the working length.\textsuperscript{17} The present study is in accordance with the study done by Hockett et al which concluded that the EndoVac had the ability to remove bacteria more effectively from root canals than traditional irrigation systems.\textsuperscript{18} Studies by Siu et al and Mitchell et al have also reported that the EndoVac System is safer and is more effective in cleaning the root canal especially in the apical third.\textsuperscript{19,20} Although with Endovac there was significant reduction of the bacterial load, it is just a mechanical aid in irrigation and does not have any anti-bacterial properties by itself like lasers. Stropko irrigation system introduced by John Stropko is an instrument used for precise control of delivery of irrigants in any dental procedure.\textsuperscript{6} In the present study, we used Stropko irrigator in conjunction with 2% CHX solution, wherein we found the colony forming units to be reduced to less than 10\textsuperscript{5} per ml as compared to the control group where the colony forming units were more than 10\textsuperscript{5} per ml.

References:

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