“Novel Disinfection Technique In Dentistry

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Abstract: The two diseases which dental surgeons deal with most frequently in their practice are caries and periodontal disease, both of bacterial aetiology. Attempts have been made to treat this infected tissue with various disinfecting agents but these have proved to be relatively ineffective.

Treatment of dental caries has therefore relied on the excision of the diseased tissue. The treatment of carious lesion with “extension for prevention” as proposed by G. V. Black is no longer tenable.

Surgical approach leads to tooth loss, removal of both infected and affected dentine, loss of esthetics, weakening of remaining crown, and further insult to pulp tissue, alteration of occlusal anatomy. When operative care is indicated it should be aimed at “prevention of extension” rather than “extension for prevention”.

In past few years a number of systems have been introduced which are designed to disinfect tooth tissue using a variety of approaches. This also addresses one of the primary problems in endodontics: that the operator must ensure that the canal is bacteria-free before sealing. The disinfection technique described in this article is called “Photo-Activated Disinfection (PAD).”

Key Words: Photo-activated disinfection, Laser, Caries, Bacteria, PAD.

Introduction
The principal aim of cavity preparation is to eliminate all cariously involved tooth structure to prevent the progression of carious process and to provide a sound structural base for restoration. The concept of minimally invasive dentistry is removal of caries with methods that minimize the loss of sound enamel and dentin. After restoration of cavity, if bacteria persist and maintain acid production, the disease will continue in the dental tissue as secondary caries and results in failure of restoration. Effective technique of caries removal is that which adequately and conservatively removes the infected dentine with bacteria and halts the carious progression. If bacteria in infected dentin could be killed, even more tissue could be retained. Latest theories regarding the rationale of carious dentin removal are also beginning to question the amounts of tissue that need to be excavated in order to successfully treat a carious lesion.

A combination of Toluuidine blue O solution (TBO) and light at 633 ± 2 nm kills bacteria in a process which has been termed ‘Photo-activated disinfection’ or PAD. A new light delivery system using this process achieved bacterial kills of the order of 10⁶ CFU/ml (100% kill) of Streptococcus mutans (the main causative agent of dental caries).

History
During early 1990’s at the Eastman Dental Institute, London (E.D.I) Prof. M. Wilson and Prof. G. Pearson first proved PAD killed Streptococcus mutans in significant number and reasoned that PAD could kill all bacteria involved in oral infections in caries, root canals, and periodontal tissues, thereby eliminating the most common oral infections.

Their principle goal was to convert their concept into a clinical procedure that dentists could use regularly and simply to stop these infections, both improving patient care and reducing dentists’ workload.

Photo-Activated Disinfection (PAD™): A simple method of disinfection easily controlled by the dentist to eliminate bacteria rapidly, providing optimum conditions for restoration placement and thus improves results in a wide range of application.

It is a simple procedure in which special liquid together with laser light kills the bacteria on a tooth surface, in a cavity or in a root canal. PAD process is energy dose dependent (Power X Time).

PAD is a breakthrough in the fight against pathogenic bacteria. It is a fast, effective and minimally invasive disinfection system which is ideal for endodontic and caries therapy.

Components of PAD:
There are 2 principal components:

1) PAD solution: A dilute solution containing pharmaceutical grade tolonium chloride. Which was established as the most effective photosensitiser packed either in dropper bottles (for caries treatment) or syringes (for delivery to root canals). (Fig 1 & 2)
2) **Red light/ Laser**: A low power 635 nm laser light source which optimally activates the solutions. (Fig 3)

**THE SYSTEM**: Consists of (Fig 3)

1) Small lightweight diode laser which has a touch sensitive control panel with reset programmes for each type of treatment to be undertaken.
2) A protected flexible cable transmits light from the laser unit to a disposable handpiece.
3) Two different handpieces have been designed for treatment of caries and endodontic therapy.
4) Attached LED curing light.

**What Are The Benefit's of PAD?**

1. Simple method
2. Time required is less for caries disinfection – 2 minutes, endodontic disinfection – 4 minutes.
3. Drilling is reduced
4. Preserves tooth material
5. In caries therapy – PAD promotes dentine remineralisation.
6. Post-treatment infection risk is reduced
7. Local analgesia may be avoided
8. Filling last longer
9. Risk of pulp exposure is reduced
10. Effective → kills > 99.9%
11. Beneficial in children and patients worried about dental treatment

**How Safe Is Pad?**

- Non toxic
- No effect on adjacent hard and soft tissue
- No sensitization of bacteria
- Selective in attacking unwanted bacteria
- No thermal effect
- No sensation Ex., heat, vibration or pain.

**Shortcomings:**

- Limited efficacy against organisms within biofilms.
- Low specificity and restricted effectiveness against a range of organisms.

**Mechanism of Action of Pad**

PAD technology consists of two components i.e., dilute solution of tolonium chloride (a vital stain) and light source of a specific wavelength (635 nm). After application of PAD solution either in caries or during endodontic treatment, it penetrates into dental hard tissue through a process of diffusion and selectively tags bacteria. When activated by the light, singlet oxygen is released. This released oxygen attaches the site on the cell wall of bacteria at point where tolonium chloride were attached. This results in bursting of bacterial cell wall leading to bacterial death. (Fig 4A, 4B, 4C & 4D)

However, the PAD process is active only when both the solution and the laser light are present. Hence, the anti-bacterial effect discontinue once the laser is switched off.

**PAD Process Depends on Following Factors**

1) Molecules of an aqueous solution of photosensitiser contacting individual bacteria involved in an infection.
2) Activation of the molecules of photosensitiser by light at 635nm producing singlet oxygen species which disrupt the membrane wall of the bacteria causing cell death.

**Factors Affecting PAD**

- Type of dye
- Dye concentration
- Irradiation parameters
  - Power, time and power density
- Species of micro-organism

**Significance Of 635nm Of Laser Output**

1) Low power 635 nm is used as light source because at 635nm, the transmission of light through demineralised dentine is 10 times more over mineralised dentin. This means that light at 635nm is transmitted satisfactorily through demineralised/infected dentin but effectively stops at the interface with sound tissue.
2) At 635nm, it kills maximum number of bacteria up to 99.9%.^4

**Effect Of PAD Against Oral Bacteria**

PAD has been shown to kill all types of bacteria commonly found in caries and root canals including:

- Streptococcus mutans
- Streptococcus sobrinus
- Streptococcus intermedius
- Actinomyces
- Lactobacillus
- Veillonella
- Prevotella intermedia
- Fusobacterium nucleatum
- E. faecalis

**Clinical Applications Of PAD**

- Dental caries
- Pit and fissure caries
- Disinfection of root canals
- Periodontal pockets
- Disinfection of impression material
- Site of peri-implantitis?

Treatment of Carious Lesion
Tooth decay is caused by bacterial infection of the tooth, if left unchecked it may cause pain and possibly tooth loss. Dental treatment to remove this infection is often by means of drilling and filling, which may only stop the decay for a limited period of time. Removing all the decay may risk pulp exposure which may require root canal treatment.

Once demineralisation of the dentine has been initiated other bacteria can migrate into the developing lesion. Generally, current treatments of caries attempt to remove all infected tissue but this cannot be guaranteed. 8,9 However Kidd et al. [1996] have proposed that the removal of only the softened and wet dentine is necessary, the effective sealing of the cavity with a restorative being sufficient to achieve ‘healing of the lesion’ as the bacteria become quiescent.10 While this is not in dispute, the difficulties in (a) determining the amount of tissue removal necessary clinically and (b) the inadequacies of most restorative materials currently available in effectively achieving a long term seal means that an effective means of disinfecting both the infected and affected tissue is highly desirable before completion of treatment.

Applications Of PAD In Caries
- Surface caries
- Pit and fissure caries
- Interproximal caries
- Moderate and deep caries
- Root caries

Procedure (Fig 5a, 5b, 5c & 5d)
- Prepare the caries lesion, remove gross caries lesion with carbide or diamond bur.
- Coat the remaining infected dentine with PAD solution
- Agitate PAD solution with brush for 60sec.
- Activate laser for 60sec at 100mW
- Wash out the lesion with sterile solution
- Restore the cavity with restorative material.

Once the bacteria is killed, bulk of the lactic acid producing complex is eliminated. Process shifts from favoring the carious lesion to complete resolution of pulpal lesion.

Endodontic Application.
Micro-organisms play a crucial role in the development of pulpal and periapical diseases. The prognosis of endodontic therapy is intimately related to the presence of bacteria within the root canal system. Micro-organisms may persist in the apical region of the root canal system despite chemomechanical preparation.11

An alternative approach to microbial killing in the root canal system is by Photo-Activated Disinfection (PAD) system which involves the use of exogenous photosensitisers such as tolonium chloride and the endodontic handpiece which has an emitter of 15mm in length and is equivalent to an ISO size 40 file along its full length. This ensures that it will pass to within 3mm of the apex with the 2°, 4° and 6° taper files currently available. This handpiece delivers low-power lasers to drive a photochemical reaction that produces reactive oxygen species which results in killing of all types of bacteria in the root canal.11 (Fig 6A, 6B & 6C)

Recently microbial killing in vivo in the root canal system has been demonstrated. While PAD can be undertaken as part of the routine disinfection of the root canal system, it also has potential use for eradicating persistent endodontic infections for
which conventional methods have been unsuccessful.  

Periodontal Treatment Using PAD

The primary etiological factor in any form of the gingival or periodontal disease is microbial dental plaque, but there is a dynamic interaction between the microbial challenge and host response. Laboratory studies have shown that the system is effective against the pathogens which cause periodontal disease.  

If this technique can be extrapolated to the clinical situation and PAD can be used in periodontal pockets then disinfection of the pathogenic bacteria may lead to a cessation of attachment loss and create an environment conducive to healing. Unlike root canal, periodontal pocket is harder to render bacteria free and harder to maintain it due to its anatomy. In addition, there is fluid in the pocket (eg, Blood, gingival crevicular fluid and pus) which could dilute the photosensitiser potentially affecting its action. It may also be difficult to access all of the pocket with light. More clinical research is required to overcome these potential problems.

Conclusion:
In dental caries the use of PAD can eliminate residual bacteria in softened dentine and provide an environment which encourages rapid healing resulting in less tissue removal and thus cavities are more conservative.

In endodontics, despite following clinical “best practice”, 20% of canals remained infected after conventional chemo-mechanical treatment. The use of PAD rendered these canals bacteria free. Further longterm studies are needed to evaluate its effectiveness in clinical practice.

References