EFFECT OF PHOTON-INDUCED PHOTOACOUSTIC STREAMING IN ROOT CANAL TREATMENT – A SYSTEMATIC REVIEW

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ABSTRACT

BACKGROUND: As per the wide advancements in dentistry, many procedures have been discovered for root canal irrigation. Among these recent advancements, photon-induced photon acoustic streaming is the most advanced and more successful than other methods. In this method, Erbium-doped yttrium aluminium, a garnet laser, is used at sub ablative power levels. Here PIPs are only used at coronal one-third of the teeth.

AIM: To study the effect of photon-induced photoacoustic streaming in root canal irrigation method.

METHODS: A literature search was performed using PubMed, PubMed Central, Europe PMC, Spie digital library using MeSH term photon-induced photoacoustic streaming and root canal irrigation. Of 281 articles screened, 23 full-text articles were assessed for eligibility, and four were taken for the qualitative analysis. The review was made according to the PRISMA guidelines. In addition, four randomised controlled trials were included for the review process.

RESULTS: The photon-induced photoacoustic streaming was compared with traditional irrigation techniques, which showed that this procedure is more effective and less time-consuming.

CONCLUSION: These photon-induced photoacoustic streaming lasers are more effective, more of a bloodless procedure and less time-consuming.

Keywords: Photon Induced Photoacoustic Streaming, Er: YAG Lasers, Root Canal Debridement.

I. INTRODUCTION

The sheer mention of the term "root canal" can make most people squirm. Whatever the term, this operation has instilled apprehension in people for millennia, with evidence indicating that humans have been attempting some root canal therapy as early as the 3rd century B.C [16]. The microbial infection is the source of overall pain and anguish. The abundance of microbial cells in canal space, ferocity, and host defences play a role in symptomatology [10]. We may not be aware of the full severity of the condition until the tooth is opened and the infection is visible [15].

The goal of root canal therapy is to keep healthy periapical tissues alive or to help them repair in restorable teeth with periodontal support [17]. The number of microbial cells and virulence and host reaction have an impact on the severity [18,19]. Microbial biofilms are most commonly detected on root canals; however, some can enter dentinal tubules to varying depths [20,21]. Root canal treatment is the chemical debridement by
mechanical instrumentation of the root canal and filling it with inert material whose aim is to restore and maintain the osteogenic protein of periradicular tissue[1]. Mostly microbial biofilms are responsible for the infection. so it is very necessary to find effective antimicrobial strategies.[4]

The most common methods for root canal debridement are mechanical files or rotary instruments followed by chemical irritants, most commonly NaOCl, EDTA.[5] The single instrumentation technique, canal disinfection with an irrigating needle, cannot deliver much volume [8]. In endodontics, laser-activated irrigation at sub ablative levels can disinfect the tubular dentin thoroughly. Despite the increased expenses of laser technology, implementing bacterial and other eradication is a tremendous breakthrough that contributes to radical transformation[9].

Innovative products such as fillers and epidemiological evidence may improve the canal system's disinfectant ability due to current elevations in root canal disinfection. Antimicrobial nanoparticles, photodynamic treatment, dental dam, gentle wave irrigations are recent advancements in root canal debridement procedures [6]. Photon-induced photoacoustic streaming could be a viable method for improving bacterial removal from the canal. [3]

In removing apically deposited dentinal debris, photon-induced photoacoustic streaming (PIPs) significantly outperforms conventional, sonic, ultrasonic, gentle wave irrigation [7]. PIPs are proven to be a suitable option for expelling the gross canal enlargement huge barrier. They also implemented removing inflamed and ulcerated epithelial tissue that seems to be prevalent in periodontal conditions. [2] This review article enlightens photon-induced photoacoustic streaming in root canal debridement procedure.

II. MATERIALS AND METHODS

Randomised control trials with interventions are included in this study.

ELIGIBILITY CRITERIA

INCLUSION CRITERIA
- Studies conducted during 2000-2021
- Full-text articles
- Studies with randomised control trial

EXCLUSION CRITERIA
- Animal studies
- Pilot studies
Studies without PIPs based measures for facilitating root canal treatment were excluded.

SEARCH STRATEGY

The following electronic databases used to find published articles on PIPs in the root canal debridement procedure include articles such as Pub Med, Bookshelf, Wiley online library, science direct, Europe PMC, SPIE digital library MDPI were taken into study for review. In addition, a literature search to collect relevant data was performed using MeSH terms "photon-induced photoacoustic streaming AND root canal treatment."

According to the Prisma guidelines, the mesh terms were altered in each search engine when the results went too many or too few.
The search yielded 280 articles, and four were independently assessed among the eligible articles.

### Table 1: Characteristics Of The Studies

<table>
<thead>
<tr>
<th>AUTHOR NAME</th>
<th>YEAR</th>
<th>PATIENT SELECTION</th>
<th>SAMPLE SIZE</th>
<th>DURATION</th>
<th>INTERVENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbara skill</td>
<td>2017</td>
<td>86 extracted single-rooted teeth which are</td>
<td>Using pips 3600/9 tip at 10 mJ or 20 mJ</td>
<td>48 hours</td>
<td>Root canals were irrigated with various levels of NaOCl. The bacterial count was performed.</td>
</tr>
<tr>
<td>Giovanni olive</td>
<td>2014</td>
<td>26 human anterior teeth</td>
<td>Siz3e of 25/06 (25 tips and .06 taper size)</td>
<td>7 days</td>
<td>they followed two irrigated protocols. Group A received two cycles of 30 seconds of 5 per cent NaOCl laser activation and one cycle of 30 seconds.</td>
</tr>
<tr>
<td>[12]</td>
<td></td>
<td></td>
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</table>
with laser activation involving the use of 17 per cent EDTA.

Narcis mantras [13] 2020 54 human of pulp necrosis with or without apical periodontitis biofilm disease Pro taper next x2 0.5 shorter than the W.L. with KfileNiTiFlex 25 48 hr They followed two irrigation groups of 5% NaOCl and 10% EDTA solution for a side vented steel needle.

Mohammad Al Shahrani [14] 2014 Sixty extracted single-rooted human teeth which are mechanically or chemically prepared. PIPs were preset to 50-microsecond pulse, 20 M.J. and power of 0.3 w. 3 weeks They followed four groups. Group 1 with no decontamination, Group 2 with PIPs and 6% NaOCl, Group 3 with pips and saline, Group 4 with 6% NaOCl.

Table 1 Characteristics of the studies that have been chosen for the systematic review. The following characteristic was studied. Name of the author, year of the study, sample number including their detail such as gender and their interventions involved in the study. All included studies were randomised controlled trials conducted strictly in the oral cavity.

Table 2: Characteristics Of Outcome And Effect Measures

<table>
<thead>
<tr>
<th>SL NO</th>
<th>AUTHOR</th>
<th>YEAR</th>
<th>EFFECT MEASURE</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Barbara skill Golob [11]</td>
<td>2017</td>
<td>A significant difference in bacterial counts was detected in all groups before and after the treatment in groups treated with 5% NaOCl 48 hrs after treatment.</td>
<td>Laser activated irrigation using 5% NaOCl, and a modified pips protocol resulted in an effective against eradicating the bacterial biofilm and removing the smear layer.</td>
</tr>
<tr>
<td>2.</td>
<td>Giovanni olive [12]</td>
<td>2014</td>
<td>Er: YAG laser activation of 5% NaOCl and 17% of EDTA was more effective than conventional irrigation for eradicating E.faecalis and preventing new bacterial growth.</td>
<td>Group A had significantly better disinfection than group B (p&lt;0.5). Disinfection also maintained better in-group A. Scanning electronic microscopic images showed the absence of bacterial biofilm remaining after using PIPs.</td>
</tr>
<tr>
<td>3.</td>
<td>Narcis mantras [13]</td>
<td>2020</td>
<td>Bacterial load reduction values, brain heart infusion agar to determine the number of facultative anaerobic strains, Columbia CNA agar with 5% sheep blood is considered to determine the total number of anaerobic bacterial stains.</td>
<td>The P-value for facultative anaerobes was found to be 0.95. meanwhile, for facultative and obligate anaerobes, it is found to be 0.37.on day 1, postoperative found to be (p=0.03), which appear to be lower for patients treated with PIPs.</td>
</tr>
</tbody>
</table>
Postoperative pain is also measured. Scanning electron microscopy and confocal microscopy examined the randomised root canal surfaces. Colony-forming units were counted. The colony-forming units analysis have the result which include group I (control) 336.18, group II (PIPs + NaOCl) 0.27, group III (PIPs + saline) 225.21 and group IV (NaOCl) 46.9. Group II had significantly lower CFU than others.

<table>
<thead>
<tr>
<th>S.L. No</th>
<th>Author and Year</th>
<th>Random Sequence Generation</th>
<th>Allocation Concealment</th>
<th>Selective Reporting</th>
<th>Incomplete Outcome Data</th>
<th>Blinding of Outcome Assessment</th>
<th>Blinding Participants and Personals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Barbara skill Golob [11]</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>Narcis mantras [13]</td>
<td>-</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>Mohammad Al Shahrani [14]</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

'+' is low-risk bias  '−' is high-risk bias  '?’ is an unclear risk of bias.

Table 3 shows the bias analysis of all the included studies. It is characterised by high-risk bias, low-risk bias and unclear risk bias. The categorisation is done according to the Cochrane risk of bias tools for randomised controlled trials.

IV. DISCUSSION

The review was aimed at knowing the effectiveness of photon-induced photoacoustic streaming in root canal irrigation. Root canal irrigation is the procedure to deliver an irrigant in the root canal system before, during or after instrumentation of the root canal. So basically, this is a procedure that flushes out plaque and bacteria.
from the space between the teeth and gum line. Root canal irrigation is a virtually pain-free procedure and causes less discomfort to the patient. This procedure is efficient and cost-effective also.

PIPs are the recent advancements in root canal irrigation procedures. It is a revolutionary method for cleaning and debriding the root canal system using erbium-doped yttrium aluminium garnet (Er: YAG) laser with a stripped tip at the sublative energy levels. PIPs can aid in the removal of microorganisms with a narrow diameter and taper. PIPs containing NaOCl can have both rapid and long term bactericidal and antimicrobial effects.

In this systematic review, four studies have been considered for assessing the effectiveness of photon-induced photoacoustic streaming in root canal irrigation. **Barbara skill Golob [11]** reported that PIPs reduce the Enterococcus faecalis in root canal disinfection while varying laser energy output and sodium hypochlorite concentration. In addition, the sequence and resting duration of the final irrigation steps were changed from the usual PIPs protocol to ensure effective removal of the smear layer. Here a total of 86 mechanically prepared single-rooted teeth were sterilised and inoculated with E. faecalis for four weeks. These were divided into nine groups and treated with Er: YAG laser utilising PIPs of 600/9 tip at different power for a particular duration. Different amounts of NaOCl were used to irrigate the root canal. After decontamination and re-incubation on an agar plate, a bacterial count was performed immediately 48 hrs later.

There was a significant difference in bacterial counts (p<0.05) in all groups before and immediately after treatment and those treated with 5% NaOCl. Scanning electron microscopy imaging revealed the lack of bacteria in that area. **Giovanni olive [12]** reported that the ability of PIPs Er: YAG laser, which reduces the bacterial colony in the root canal when compared to regular irrigation, and they have conducted this in an in vivo manner.

Here 54 patients were taken who have complaints of pulp necrosis or periodontitis related disease. They have randomly assigned to two groups with 27 patients in each group. First, shaping is done by ProGlider and proper. Then irrigation was done with 5% NaOCl and 10 per cent of EDTA. Intracanal samples were taken before and after irrigation. Finally, the microbiological examination was completed. **Narcis mantras [13]** reported that the laser-activated irrigation with the traditional method using the photon-induced photoacoustic streaming tip. Here the study mainly focused on bacterial film removal based on laser-activated irrigation's capacity. Here 26 human teeth were sterilised and infected with Enterococcus faecalis. They are incubated for four weeks using a master apical file. They were divided into two groups, of which group A got 30 seconds of laser activation cycle which involved 5% NaOCl, and 30 seconds of laser activation cycle, which involved 17% EDTA. Meantime, group B got two 30-second cycles of 5% NaOCl and 17% EDTA irrigation given with a 25 gauge needle via syringe. They have concluded that group A disinfected substantially better than group B (p<0.5). After 48 hours, the culture findings revealed that disinfection was sustained better in group A. After laser-activated irrigation with PIPs scanning electron microscopic pictures revealed that no bacterial biofilm has remained.

Mohammad Al Shahrani [14] reported that an in vitro study has been done in a heavily colonised decontaminating root canal system with the help of photon-induced photoacoustic streaming where Er: YAG laser is used. In this method, single-rooted extracted human teeth were mechanically prepared and then assigned to four groups with different irrigation methods. Then PIPs were used with different power for a particular time duration. Finally, the remaining microorganisms from all specimens were collected and recovered using CFUs.

**V. CONCLUSION**

There is conclusive evidence that photon-induced photoacoustic streaming shows promising results in root canal irrigation with less pain, more prone to any prior infection.

**VI. REFERENCES**


