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Ultrasonic vs. Laser Irrigation Activation: A Systematic Review on Debris Removal Efficacy in Root Canal Cleaning and Shaping

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KEYWORDS

Irrigation Activation, Ultrasonic Technique, Protocols for irrigation, Laser irrigation

ABSTRACT:

Introduction: Root canal cleaning and shaping represent critical stages in endodontic therapy, their significance lies at preserving dental health and preventing tooth loss. These stages involve the intricate process of removing infected or damaged pulp tissue from root canal system and subsequently shaping and disinfecting this intricate network of passages.

Objectives: To do a comparative analysis to find out the efficacy of debris removal in root canal cleaning and shaping using ultrasonic and laser irrigation activation techniques.

Methods: PICO Question: Population: Patients undergoing root canal therapy. Intervention: Ultrasonic irrigation activation during root canal therapy. Comparison: Laser irrigation activation during root canal therapy. Outcome: Debris removal efficacy in root canal cleaning and shaping. A comprehensive search strategy was developed using a combination of keywords and Medical Subject Headings (MeSH) terms. The search strategy was designed to capture relevant articles comparing ultrasonic and laser irrigation activation in root canal therapy.

Results: Debris removal during root canal cleaning and shaping is a critical factor influencing the success of endodontic therapy. In recent years, attention has been directed in innovative techniques. We had provide a comparative analysis of two methods based on the available evidence and insights from various authors

Conclusions: Comparative analysis of ultrasonic and laser irrigation activation for debris removal during root canal therapy is an evolving field, available evidence suggests that both techniques have potential benefits

1. Introduction

Root canal cleaning and shaping represent critical stages in endodontic therapy, with their significance lying at the very core of preserving dental health and preventing tooth loss [1]. These stages involve the intricate process of removing infected or damaged pulp tissue from within the root canal system and subsequently shaping and disinfecting this intricate network of passages [2]. Successful cleaning and shaping are essential prerequisites for achieving positive treatment outcomes, as they facilitate the removal of microbial pathogens and debris, creating an environment conducive to healing and

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restoration [3]. Among the multifaceted factors influencing the efficacy of root canal therapy, debris removal stands as a paramount concern, as residual debris can serve as a reservoir for pathogens, thereby compromising the overall success of the treatment [4].

In the realm of endodontics, a myriad of methods and irrigation protocols have been developed to address the challenges associated with debris removal during root canal cleaning and shaping. These techniques span from traditional syringe-based irrigation to more advanced strategies employing sonic or ultrasonic activation, and even cutting-edge laser technology [5]. Each method comes with its own set of advantages and limitations, making it crucial for dental practitioners to have a comprehensive understanding of their relative efficacies in debris removal [6]. Moreover, selecting the most suitable technique and irrigation protocol plays a pivotal role in achieving optimal outcomes in root canal therapy [7].

The motivation behind conducting this systematic review stems from the need to comprehensively evaluate and compare two promising techniques—ultrasonic and laser irrigation activation—in the context of their efficacy for debris removal during root canal therapy. The review aims to synthesize existing evidence, providing a nuanced analysis of these innovative methods [8]. By critically examining their advantages, disadvantages, and clinical implications, it aims to offer valuable insights to endodontic professionals who strive to improve patient outcomes through evidence-based decision-making.

2. Objectives

Despite the pivotal role that debris removal plays in root canal therapy and the variety of techniques available, there exists a relative paucity of comprehensive studies directly comparing the efficacy of ultrasonic and laser irrigation activation. While both techniques hold significant promise, limited research has explored their comparative performance in the critical task of debris removal within the root canal system [9]. This review thus underscores the urgency of addressing this gap in the literature, providing a foundation for more informed clinical practices and further research endeavors in the field of endodontics.

3. Methods

3.1Protocol Registration:

This systematic review was registered with the Open Science Framework (OSF) under the project title "Ultrasonic vs. Laser Irrigation Activation: A Comparative Study on Debris Removal Efficacy in Root Canal Cleaning and Shaping" (Registration ID: [https://doi.org/10.17605/OSF.IO/CF8JG]).

3.2 PICO Question:

Population: Patients undergoing root canal therapy.
Intervention: Ultrasonic irrigation activation during root canal therapy.
Comparison: Laser irrigation activation during root canal therapy.
Outcome: Debris removal efficacy in root canal cleaning and shaping.

3.3 Information Sources:

PubMed/MEDLINE
Cochrane Library
Embase
Web of Science
Scopus

3.4 Search Strategy:

A comprehensive search strategy was developed using a combination of keywords and Medical Subject Headings (MeSH) terms. The search strategy was designed to capture relevant articles comparing ultrasonic and laser irrigation activation in root canal therapy. The following is an example of the search strategy used for PubMed:
("Ultrasonic" OR "Sonics" OR "Ultrasonics" OR "Ultrasonography"OR"Ultrasonography,Interventional")AND("Laser" OR "Lasers, Semiconductor" OR "Lasers, Gas" OR "Lasers, Solid-State" OR "Lasers, Excimer" OR "Lasers, Dye" OR "Lasers, CO2") AND
("Root Canal Therapy" OR "Endodontics" OR "Root Canal Filling Materials" OR "Root Canal Preparation")
The search was conducted by two independent reviewers to ensure its comprehensiveness and minimize selection bias.

3.5 Selection Process:

Initial Screening: Titles and abstracts of all identified articles were independently screened by two reviewers to assess their relevance to the research question.

Full-Text Review: Full texts of potentially relevant articles were retrieved and assessed by two reviewers against predefined inclusion and exclusion criteria. Any disagreements were resolved through discussion or consultation with a third reviewer.

Data Extraction: Data from selected articles, including study design, sample size, intervention details, and outcomes, were extracted using a standardized data extraction form.

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Risk of Bias Assessment: The risk of bias in included studies was evaluated using appropriate tools (e.g., Cochrane Risk of Bias tool for randomized controlled trials). Two reviewers independently assessed the risk of bias, and any discrepancies were resolved through consensus.

Data Synthesis: Qualitative and quantitative synthesis (meta-analysis) of the included studies was conducted where applicable.
Publication Bias: Publication bias was assessed using funnel plots and statistical tests, if a sufficient number of studies were included.

Quality of Evidence: The quality of evidence for each outcome was evaluated using established criteria (e.g., GRADE approach).

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed throughout the review process to ensure transparency and rigor as shown in Figure1

4. Results

Study Selection

Figure 1 presents a flowchart of the systematic review process. A total of 18 studies met the criteria for the inclusion.

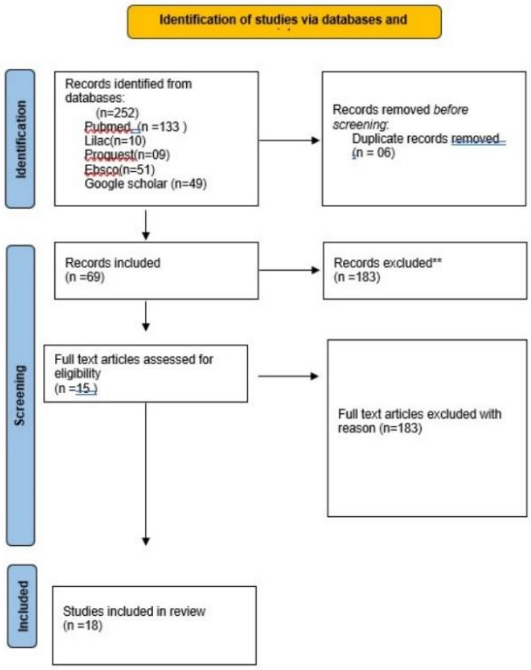

Figure 1: Flowchart summarization of how thw systematic review was conducted under PRISMA guidelines

5. Discussion

Debris removal during root canal cleaning and shaping is a critical factor influencing the success of endodontic therapy. In recent years, attention has been directed towards innovative techniques such as ultrasonic and laser irrigation activation for enhancing the efficacy of debris removal. This discussion aims to provide a comparative analysis of these two methods based on the available evidence and insights from various authors.

Several review articles have delved into the comparative analysis of ultrasonic and laser irrigation activation in the context of debris removal during root canal therapy. While there is a dearth of systematic reviews explicitly focusing on this comparison, existing literature provides valuable insights. A review by Plotino et al. in 2016 [10] explored new technologies to improve root canal disinfection and highlighted the potential of ultrasonic and laser activation. They noted that ultrasonic irrigation can create acoustic streaming, aiding in debris removal, while laser activation can offer precise and controlled cleaning. However, the review did not provide a direct comparison between the two methods.

In contrast, another review by Gu et al. in 2013 [11] evaluated the efficacy of laser-activated irrigation in root canal disinfection. They emphasized the ability of laser systems to effectively remove debris and debris-smear layers. While this review did not directly compare ultrasonic and laser methods, it shed light on the promising role of laser activation in debris removal.

Various authors have shared their views on these techniques as well. Ahmad et al. [12] emphasized the role of ultrasonic debridement in root canal cleaning, highlighting acoustic streaming as a mechanism for debris removal. In their 2015 study, Wang et al. [13] explored the cleaning efficacy of laser-activated irrigation and found it to be effective in removing debris and biofilms from root canals. These studies provided valuable insights into the potential advantages of each technique.

However, it is essential to note that direct comparative studies between ultrasonic and laser irrigation activation for debris removal are relatively limited. Recent articles, such as the study by Neelakantan et al. in 2020 [14], have attempted to bridge this gap. They compared the efficacy of ultrasonic and laser activation in debris removal and found that both methods were effective, with no statistically significant difference between them.

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This study adds to the evolving body of literature on this topic and suggests that the choice between ultrasonic and laser activation may depend on various clinical factors and practitioner preferences.

Table 1 : : Evaluation of the collected data from the included articles

Sr No.	Author/ Year	Sample Size	Devices tested	Control used	Variables evaluated (Parameters)	Outcome
1	Prasada LK	112	Ultrasonic Diode laser	Conventional irrigation method	Reduction of E. Faecalis	NaOCl + ultrasonic activation> Diode laser
2	Uros Josic		Sonic Ultrasonic Er:Yag laser	Conventional irrigation method	Cleaning Efficacy	Sonic Ultrasonic Er:Yag laser > Conventional irrigation method
3	J. Verstraeten	30	Ultrasonic Er:Yag laser	Conventional LAI	Cleaning efficacy of different irrigation activation technique	Lowest debris values were observed in the laser groups, no significant dif- ferences in the vol% of accumulated hard tissue debris after activation
4	Anand SUSILA		EndoVac, EndoActivator, Ultrasonic, MDA (manual dynamic agitation), CUI (Continuous Ultrasonic Irrigation) and PUI (Passive Ultrasonic Irrigation	Conventional non-activated Irrigation	Canal and isthmus cleanliness	Mechanical active irrigation devices> Conventional

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						non-activated Irrigation
5	Saime A Aydin	72	Er,Cr:YSGG laser Ultrasonic Photodynamic therapy (PDT)	standard needle irrigation	Removal of the E. faecalis biofilm	LAI and PUI of NaOCl and PUI of CHX> PDT on root canal disinfection
6	Vijetha Badami		Laser activated irrigation, Ultrasonic activated irrigation		Efficacy of irrigation activation	LAI > UAI
7	Jonathan Race		Er,Cr:YSGG laser and ultrasonic acti-vated irrigation	Conventional irrigation method	Eradicating a mixed-species biofilm	LAI= UAI
8	Vatanpour M	63	Conventional syringe irrigation, passive ultrasonic irrigation, and SWEEPS (Shock wave enhanced emission photoacoustic streaming) irrigation.	Conventional syringe irrigation	smear layer and debris removal	SWEEPS and passive ultrasonic irrigation> conventional syringe irrigation. passive ultrasonic Irrigation =SWEEPS
9	Manuele Mancin	85	Final activation technique (EndoActivator, EA), Ultrasonic (EndoUltra, PUI) and Laser (PIPS and SWEEPS).		smear layer and debris removal	PIPS and SWEEPS>EA. PIPS>PUI
10	Hüseyin Gündüz	60	laser and ultrasonic irrigation activation	Conventional needle irrigation	smear and debris removal efficiency	laser activation group> ultrasonic activation and control groups
11	R. C. D. Swimberghe		EndoActivator		Hydrogel removal	LAI group> UAI.

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			(EA), Eddy, ultrasonically activated irrigation, laser activated irrigation (LAI)	Conventional needle irrigation		Eddy>NI & EA
12	Uslu G	105	Conventional needle irrigation (CNI), sonic irrigation device of EDDY, passive ultrasonic irrigation (PUI), PIPS and SWEEPS techniques	Conventional needle irrigation	smear layer removal and tubular penetration	PIPS>PUI & EDDY
13	Sharonit Sahar-Helft	60	positive-pressure irrigation, with a syringe,PUI inserted1 mm short of the working length, passive ultrasonic irrigation, inserted in the upper coronal third of the root, Er:YAG laser-activated irrigation, inserted 1 mm short of the working length, Er:YAG laser-activated irrigation, inserted in the upper coronal third of the root	Conventional needle irrigation	Smear layer removal	LAI inserted either at the working length or only in the coronal upper third of the root.
14	L. B. A YRANCI	48	laser-assisted irrigation (LAI), passive ultrasonic irrigation (PUI)	Conventional needle irrigation	Smear layer removal	LAI>PUI
15	Abdollah Ghorbanzadeh	144	conventional irrigation (CI),	Conventional irrigation	Smear layer removal	CI+smear layer

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			smear layer removal plus conventional irrigation (gold standard), passive ultrasonic agitation (PUA) and Nd:YAG laser activated irrigation (LAI)			removal>PUA , LAI
16	Sathish Abraham	40	Diode laser, endoActivator, and passive ultrasonics	Conventional irrigation with 0.2% chitosan	Smear layer removal at the apical third from root canals with 0.2% chitosan	Diode laser and endoActivator with 0.2% chitosan>PUI
17	Aysenur Kamaci	75	conventional irrigation, irrigation activated by ultrasound, Er:YAG laser with photon-induced photoacoustic streaming (PIPS) tip, and 2 diode laser techniques	Conventional irrigation	efficacy of debris removal	UAI>CI & other techniques

Conclusion:

In conclusion, while the comparative analysis of ultrasonic and laser irrigation activation for debris removal during root canal therapy is an evolving field, available evidence suggests that both techniques have potential benefits. Further research, including systematic reviews and well-designed comparative studies, is needed to provide a more definitive understanding of their relative efficacies and clinical implications.

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