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A Systematic Review Comparing the Efficacy of Active Irrigation Techniques versus Passive Techniques in Bacterial Removal from Root Canals

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KEYWORDS

Endodontics, root canal treatment, active irrigation, passive irrigation, debris removal, disinfection, systematic review, randomized controlled trials, limitations.

ABSTRACT:

Introduction: Endodontic treatment involves crucial steps like irrigation to eliminate debris and disinfect the root canal system. This review explores the comparative effectiveness of active and passive irrigation methods, considering factors like debris removal, disinfection, and overall efficacy.

Methodology: A systematic review was conducted, focusing on studies comparing active and passive irrigation in endodontic procedures. Electronic searches identified randomized controlled trials, and a rigorous selection process ensured eligibility criteria were met. Data extraction and independent evaluations aimed to minimize bias.

Results: Studies primarily relied on indirect evidence like microbiological counts, with limited data on patient-relevant outcomes such as pain and swelling. The analysis was constrained by a scarcity of high-quality studies, impacting the ability to aggregate data. Efforts were made to reduce bias, but potential unpublished studies and incomplete reports posed limitations.

Conclusion: Active irrigation, particularly using methods like sonic or ultrasonic irrigation, demonstrated advantages in debris elimination and disinfection compared to passive methods. However, the review acknowledges limitations due to the scarcity and quality of available studies. Tailoring irrigation methods to specific scenarios and considering the clinician's expertise are recommended.

INTRODUCTION

Root canal treatment is a crucial aspect of endodontic therapy aimed at preserving teeth afflicted by pulp and periapical pathologies.[1] The success of this procedure heavily depends on effective disinfection of the root canal system. One of the pivotal challenges faced in endodontics is the removal of bacteria from intricate root canal anatomy, where microbial biofilms can persist despite meticulous cleaning and shaping.[2]

In the pursuit of enhanced bacterial elimination, various irrigation techniques have been developed and employed in endodontic practice.[3] These techniques can be broadly categorized into active and passive irrigation methods. Active irrigation involves the dynamic movement of irrigating solutions within the root canal space, facilitated by instruments such as needles, ultrasonic devices, or laser-activated systems. In contrast, passive irrigation relies on the inherent flow of irrigants without additional mechanical activation.[4,5]

The comparative effectiveness of active and passive irrigation techniques in bacterial removal from root canals is a subject of considerable interest within the dental research community.[6] Understanding the strengths and limitations of these methods is essential

Journal of Chemical Health Risks

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for clinicians seeking to optimize the outcome of root canal treatments.[7]

This systematic review aims to critically evaluate and synthesize the existing evidence on active and passive irrigation techniques in the context of bacterial elimination from root canals.[8] By analyzing relevant studies, we seek to provide a comprehensive overview of the current state of knowledge, identify potential gaps in the literature, and offer insights that may inform clinical decision-making in endodontic practice.[9] The synthesis of available evidence will contribute to a more nuanced understanding of irrigation techniques, potentially guiding future research endeavors and influencing clinical protocols for enhanced root canal disinfection.[10]

AIM

To compare the efficacy of different irrigation system in people undergoing endodontic therapy.

OBJECTIVE

1. Analyse different irrigation system
2. Classification of irrigation system as active and passive
3. Qualitative analysis and comparison of different irrigation system.

DEFINING THE RESEARCH QUESTION

PICOS OF THE STUDY

In this study, the

P-Population included patients undergoing endodontic therapy or root canal treatment,

I-Intervention focused on active irrigation or activated irrigation devices,

C-Comparison involved manual irrigation devices, including syringe irrigation, needles, cannula, end venting, side venting, and other synonyms.

O-Outcomes considered were beneficial or adverse reactions, time consumption, ease of use, favourable or good outcomes, and antimicrobial efficacy, among others.

S-Study design included randomised controlled trials and clinical studies conducted in-vivo or ex-vivo.

The systematic review focused on the comparative effectiveness of active and passive irrigation techniques in the removal of bacteria from root canals. As a common scale for measuring different irrigation systems was lacking in the identified studies, a qualitative analysis was employed. The primary databases used for the literature search were PubMed, Cochrane, and Scopus. The Medical Subject Headings (MeSH) term used in PubMed included words similar to "RCT IRRIGANT."

To refine the search, filters were applied based on the time frame of the study, study design (Randomized Controlled Trials), geographical location, and language (English). Different combinations of keywords were utilized in separate searches on PubMed, Medline, Scopus, and Cochrane. In the final screening, 21 potential reports were examined, and 5 studies were included, all of which explored the effects of various irrigation systems in root canal treatment.

All included studies adhered to a randomized controlled trial design, allowing for a rigorous comparison of different irrigation systems. The participants in these studies were both genders aged 18 and above undergoing endodontic treatment. The commonality across the studies lay in the evaluation of different irrigation systems on teeth undergoing endodontic treatment.

Exclusion criteria led to the removal of 190 studies during the final screening, as they did not meet eligibility criteria or failed to address the PICO (Population, Intervention, Comparison, Outcome) question of the study. Excluded studies were typically those in languages other than English, and grey literature and conference proceedings were not considered.

Data collection involved extracting key information from the included studies, such as sample size, type of teeth, activation devices used, controls utilized, primary outcomes, follow-up data (if applicable), and any secondary inferences. Variables of interest included post-operative pain, reduction in cultivable bacteria, canal cleanliness, isthmus cleanliness, debris removal, apical debris extrusion, delivery of irrigant to full working length, and long-term effects on healing and success.

SEARCH STRATEGY

Eligibility Criteria

Inclusion Criteria

Studies evaluating at least one mechanical active irrigation device and one conventional irrigation.

Outcome measures including reduction in post-operative pain, reduction in cultivable bacteria, canal and isthmus cleanliness, debris removal, apical debris

extrusion, delivery of irrigant to full working length, and long-term effects on healing and success.
Only randomized controlled trials and clinical studies conducted in-vivo and ex-vivo were included.
Articles published in the English language or those with available English translation.

Exclusion Criteria
Conference proceedings, personal communications, letters to editors, case reports, series, and other unpeer-reviewed literature were excluded.
Studies related to photo or laser activation of irrigants were excluded.

Search Terms
The search involved using Boolean operators "AND" and "OR" on PubMed and Medline, utilizing terms like "active irrigation OR passive irrigation." Mesh terms retrieved from PubMed were combined with Boolean operators. For Cochrane Library, the search query was "active irrigation and passive irrigation in rct." For Scopus, loose phrases with double question marks were used, e.g., "active irrigation in RCT??" "passive irrigation in RCT??" Proximity operators were also employed in Scopus searches (Pre/n: irrigation Pre/2 rct).

Keywords Used
Medical Subject Headings (MeSH) terms were employed for root canal irrigants. Relevant keywords included:
Root Canal Irrigants
Canal Irrigant, Root
Canal Irrigants, Root
Irrigant, Root Canal
Irrigants, Root Canal
Root Canal Medicament
Root Canal Medicaments
Canal Medicament, Root
Canal Medicaments, Root
Medicament, Root Canal
Medicaments, Root Canal
The MeSH Unique ID for these terms is D012388, and the tree numbers include D25.800, D27.505.954.122.425.300.500, D27.720.274.300.500, J01.637.051.800. The studies considered in the systematic review focused on these keywords and MeSH terms to ensure a comprehensive and relevant analysis according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

RESULTS
The systematic search process identified a total of 351 articles, which underwent initial screening to remove duplicates (n=203). Subsequently, 148 articles were evaluated based on title and abstract, leading to the exclusion of 50 articles. The remaining 9 articles were further examined in detail, resulting in the inclusion of 5 studies that aligned with the PICO format.

Study Characteristics
Included Studies
Five randomized controlled trials (RCTs) were included after a thorough examination of the full text.

Study Design
All 5 studies employed a randomized controlled trial design with parallel arm groups.

Location of the Studies
The studies were conducted in diverse locations: Bolu, Turkey; Ismailia, Egypt; Çanakkale, Turkey; Guilin, China; and Wardha, India.

Participants
Study participants encompassed both genders, aged 18 to 80, or extracted teeth undergoing endodontic treatment. Specific details about the context of intervention were often limited.

Overview of Intervention Type
Common trends across the studies included evaluating percentage of bacteria, percentage of cleanliness, Visual Analogue Scale (VAS), clinical evaluation, and debris on the canal wall. The literature lacked a standard intervention method.

Exclusion of Studies
Nine studies were excluded during the final screening, primarily due to not meeting eligibility criteria or failing to address the PICO question. Exclusions were also made for studies in languages other than English, and grey literature or conference proceedings.

Journal of Chemical Health Risks
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JCHR (2024) 14(1), 2098-2108 | ISSN:2251-6727

Overview of Outcome

Included Studies & Outcomes

KoşumcuAkdere: No irrigation method provided 100% bacterial elimination; no significant difference between methods in terms of percentage of dead bacteria.[11]

O. K. Montaser et al: Three irrigation techniques improved anastomosis cleanliness; EDDY achieved the best overall cleanliness.[12]

Erhan et al: SWEEPS laser irrigation showed lower postoperative pain scores compared to other activation systems.[13]

Zhenyu et al: Mtwo Ni-Ti rotary instrument combined with ultrasonic irrigation showed short and long-term efficacy in elderly patients.[14]

Sheetal Ghivari and Girish Kubasad: Comparison of three irrigating needle designs for debris removal.[15]

Risk of Bias

The Risk of Bias tool (RoB2.0) indicated an overall low risk for each study. Randomization was explicitly mentioned in one study, and unclear in others. Allocation bias was low in all studies. Blinding (performance and detection bias) was not clear in any study. Attrition bias was low, with no reported loss of follow-up but insufficient information on missing data handling.

Primary and Secondary Outcomes

Primary outcomes included percentage of bacteria and cleanliness of the canal. Secondary outcomes included pain scale using VAS.

PRISMA Flow Diagram

A PRISMA flow diagram summarizing the study selection process is presented in Figure 1, providing a visual representation of the systematic review's search and screening stages.

Figure 1: traffic light plot for determining risk of bias

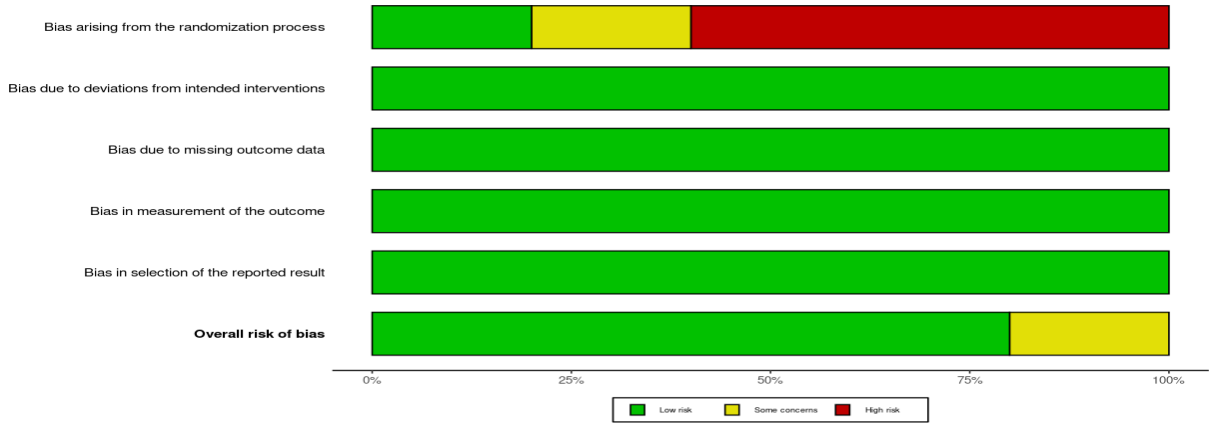

Fig 2: representing pool risk of bias for all studies

Journal of Chemical Health Risks

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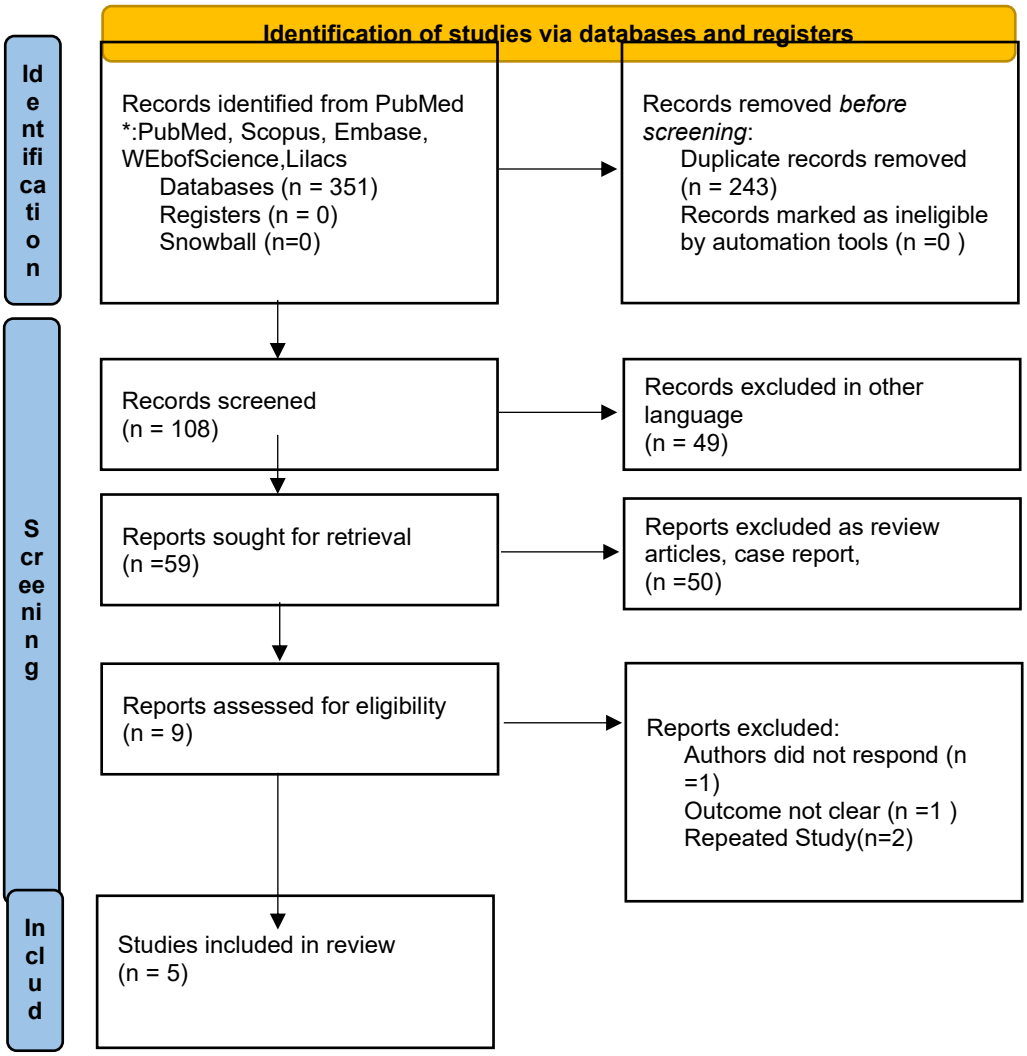

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit:http://www.prisma-statement.org/

Study ID	Location	Blinding & Randomization	Sample size	Duration of the study	Primary outcome	Secondary outcome scale	Comparison group	Significance outcome
S Sheetal 11 20	India	Not clear	30 teeth		Debris score		25-gauge irrigation needle designs – brush-covered Navi Tip FX (Group I), side-vented needle RC	It can be concluded that all the needle designs Tested were effective in certain regions

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(1), 2098-2108 | ISSN:2251-6727

							Twents (Group II) and single-beveled (Group III) irrigating Needles – were tested for their efficiency in debris removal in three different parts of the root Cana	of the root canal with apical third uncleaned. Side-vented Needle by creating turbulence removed debris effectively in coronal and middle thirds
ZhZenyu Tang 12 2015	China	Not Clear	300	6 month, 12 month	Visual Analogue Scale	Clinical symptoms observed by physician X ray	Group A Mtwo Ni-Ti rotary instrument combined with ultrasonic irrigation of a 2.5% naocl solution. Group B instrument combined with ultrasonic irrigation of an active silver ion Antibacterial solution. Group C used the same instrument combined with syringe irrigation of a 2.5% naocl solution	The self-assessed pain levels for Group A and B were significantly lower than group C. The incidence of postoperative acute reactions after seven days for Group A and B were significantly lower than those of group C. The effective rates after six and twelve months did not differ Among these groups. The single-visit root canal treatment with a nickel-titanium rotary instrument combined with

Journal of Chemical Health Risks

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JCHR (2024) 14(1), 2098-2108 | ISSN:2251-6727

								ultrasonic Irrigation for elderly patients with chronic periapical periodontitis achieved short and long term efficacy and stability.
Erh Eran Erkan 13 2 2021	Istanbul Turkey	Simple randomization	33		VAS		Laser irrigation activation system [shock wave-enhanced emission photo-acoustic streaming (SWEEPS)] in terms of postoperative pain after primary root canal treatment compared with other techniques, namely photon-induced photo-acoustic streaming (PIPS), sonic system with EDDY, passive ultrasonic system (PUI), and manual dynamic activation (MDA).	Laser-activated irrigation systems provided lower Postoperative pain scores and levels compared to the other activation systems. The MDA group had the highest pain scores And incidence at the end of the seventh day
O O.K Montaser 14		Not Ckear	20		Percentage cleanliness		Group 1: NA, group 2: Irrisafe, group 3: EDDY. Stereomicroscopic images	All three irrigation techniques signifcantly improved anastomosis cleanliness ($p<0.001$). Both

Journal of Chemical Health Risks

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JCHR (2024) 14(1), 2098-2108 | ISSN:2251-6727

							Of anastomoses were taken after instrumentation and after irrigant activation	activation Techniques were signifcantly better than the control group at all levels. Intergroup comparison revealed that eddysignificantly achieved the best overall anastomosis cleanliness
S. KoşumcuAkdere · Z. Uğur Aydin · D. Erdönmez 15 2 2022		Not Clear	79		Percentage of bacteria		Standard needle irrigation (SNI), EDDY, passive ultrasonic irrigation (PUI), photon-induced photoacoustic streaming (PIPS), and shock wave enhanced emission photoacoustic streaming (SWEEPS) activation on the teeth with simulated internal root resorption (IRR) and contaminated with Enterococcus faecalis (E. Faecalis) using confocal laser scanning	None of the irrigation activation methods tested provided 100% bacterial elimination. There was no signifcantdifference between the irrigation activation methods tested in terms of the percentage of dead bacteria (P>0.05). In irrigation activation methods other than PIPS, there was no signifcantdifference in the percentage of dead bacteria between the coronal, middle, and apical regions of the root

DISCUSSION

Root Canal Treatment (RCT) is pivotal for preserving teeth affected by various dental conditions, necessitating effective bacterial elimination and prevention of re-infection. As dental practitioners aim to optimize outcomes, the choice between active and passive irrigation methods becomes a critical consideration. This discussion synthesizes findings from

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(1), 2098-2108 | ISSN:2251-6727

studies following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, exploring the nuances of irrigation techniques in root canal therapy.

Active vs. Passive Irrigation

The ongoing debate surrounding active and passive irrigation methods underscores the need for evidence-based insights.[16] Studies within the PRISMA framework indicate that active irrigation, involving techniques like ultrasonic or sonic activation, may offer superior efficacy in debris and bacteria elimination compared to passive methods.[17] However, the landscape is nuanced, with some investigations reporting insignificant differences in clinical outcomes between the two approaches.[18]

Key Findings from PRISMA-Compliant Studies

Tang et al. (2015): Demonstrated successful single-visit RCT for elderly patients using Ni-Ti rotary instruments and ultrasonic irrigation solutions, highlighting the importance of tailored approaches.[14]

Ghivari&Kubasad (2011): Emphasized the efficacy of end-vented needles in debris removal from root canals, a crucial aspect in achieving a sanitized canal.[15]

Montaser et al. (2023): Identified passive ultrasonic activation as the most effective in cleaning root canal anastomoses, shedding light on the intricacies of root canal anatomy.[12]

KoşumcuAkdere et al. (2023): Proposed combining irrigation activation with photodynamic therapy for enhanced antimicrobial properties, introducing an innovative dimension to treatment strategies.[11]

Erkan et al. (2022): Explored postoperative pain reduction, indicating comparable outcomes among various irrigation activation techniques, sparking discussions on patient comfort and experience.[13]

The evidence synthesized from PRISMA-compliant studies underscores the need for personalized approaches in irrigation techniques based on patient demographics, anatomical considerations, and microbial load.[19] The ongoing discourse surrounding active versus passive irrigation methods invites further research, emphasizing the importance of standardized protocols and comprehensive understanding across diverse clinical scenarios. Future investigations should delve into these complexities, guiding clinicians towards optimized strategies for root canal therapy.[20,21]

The analysis faced limitations primarily characterized by the reliance on indirect evidence, with a scarcity of data on patient-centric outcomes like pain and swelling.[22] The studies were hindered by a shortage and suboptimal quality, impacting the ability to aggregate comprehensive data. The review acknowledged uncertain reliability in certain areas and implemented thorough electronic searches to reduce bias. The potential existence of unpublished studies and the limited evaluation of publication bias introduced complexities.[23-25] Despite efforts to minimize bias, challenges in trial details assessment and incomplete reports were acknowledged openly. In conclusion, the study navigated constraints, emphasizing transparency in the face of limitations for a nuanced interpretation.[26]

The recommendations underscore the need for a tailored approach in selecting irrigation methods in endodontic treatment. The choice between active and passive irrigation hinges on factors such as the extent of contamination and the practitioner's expertise.[27] Active irrigation, particularly methods like sonic or ultrasonic irrigation, is favored for scenarios with substantial debris. Passive irrigation suffices when the root canal is relatively uncontaminated.[28] Combining both methods may optimize outcomes, with passive irrigation distributing irrigants and active irrigation removing residual debris. The exploration of advanced techniques like continuous-wave irrigation is suggested for potential benefits in cleaning and disinfection. Overall, the recommendation emphasizes a case-specific approach, considering the clinician's preferences and the unique aspects of each situation.[29-31]

CONCLUSION

Irrigation plays a pivotal role in endodontic treatment, contributing to debris removal and root canal disinfection. Active irrigation, utilizing mechanical energy, is favored over passive irrigation due to its enhanced efficacy in debris elimination and biofilm disruption. The mechanical energy generated by active methods, such as sonic or ultrasonic irrigation, aids in flushing debris from the canal, improving disinfection. Active irrigation methods also offer efficiency benefits in terms of resource utilization and reduced therapy duration.

Journal of Chemical Health Risks

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JCHR (2024) 14(1), 2098-2108 | ISSN:2251-6727

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