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(Review Article)

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Effectiveness of LED-curing light photodynamic therapy with curcumin (cur-aPDT) as a disinfection method in root canal

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Abstract

Background: Root canal treatment (RCT) is an endodontic treatment that reduces microbial growth and provides a suitable environment to induce periradicular healing. The prevalence of root canal treatment failure caused by *Enterococcus faecalis* bacteria reaches 90% because the bacteria form biofilms to defend themselves against antibacterial agents. Although the conventional use of NaOCl as a disinfectant has been well-known for a long time, improved disinfection methods are needed to optimize root canal treatment. One of the treatments that can provide better results through reducing the number of microbes is photodynamic therapy (aPDT) mediated with curcumin compound (Cur- aPDT) as a photosensitizer. Curcumin is a compound that can be used as a root canal disinfecting agent which can increase dentin bond strength through its antimicrobial and antioxidant activities with its natural pigment as a photosensitizer.

Materials and Methods: The literature review was carried out on PUBMED, MDPI, and Sciencedirect databases with a limit of 2019-2024 to identify published research on the antimicrobial effectiveness of Cur-aPDT as a root canal disinfection method.

Conclusion: This review shows that Cur-aPDT is an effective method to disinfect root canals.

Keywords: LED-Curing Light; Photodynamic Therapy; Curcumin; Root Canal Disinfection; Endodontic Treatment

1. Introduction

Root canal treatment (RCT) is a general dental procedure used to repair and save severely infected teeth in order to prevent recurrent infections from microorganisms. RCT has several main stages, including pulp chamber opening, root canal preparation, and root canal filling. The root canal preparation consists of shaping and root canal cleaning [1]. The success of RCT depends on various factors, including the condition of the tooth and endodontic procedures performed. Overall, RCT has a high success rate, but complications such as pain and infection can still occur in the post-treatment period [2].

Irrigation and mechanical instrumentation are important factors in successful RCT that can remove pulp tissue remnants and also remove smear layers and debris. Currently, conventional irrigation using NaOCl is still the gold standard of RCT, but it has the disadvantage of cleaning the apical area because the irrigation material cannot easily reach the area [1]. The complexity of the root canal creates a higher risk of pulp tissue remnants, bacteria and smear layer being retained in the root canal due to the difficulty of removing and disinfecting all small branches and crevices that may contain microorganisms [5]. Proper root canal instrumentation and sufficient irrigation with NaOCl can reduce the number of bacteria, but it is unable to completely eliminate *Enterococcus faecalis* bacteria in the root canal [6]. A study showed that irrigation using NaOCl can lead to failure in removing pulp tissue remnants or reaching the entire

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affected area, which can cause persistent recurrent infection and chronic inflammation, as well as local tissue damage and severe pain if it is extruded. This makes the risk of RCT failure also high [7].

Several studies have shown that *Enterococcus faecalis* is more common in cases of failed endodontic treatment compared to cases of primary infection. However, among all cases with pain and infection post endodontic therapy, *Enterococcus faecalis* was found most frequently, with a high prevalence value of 90%. Meanwhile, among all primary endodontic infection cases, *Enterococcus faecalis* was found more in asymptomatic cases as compared to symptomatic cases. Therefore, several methods were developed to improve root canal cleaning, one of them is using LED-curing light [3].

Photodynamic therapy (PDT) has expanded in the endodontic field due to its antimicrobial capabilities. PDT is defined as a procedure of light-induced inactivation of cells and microorganisms known as light activated disinfection (LAD) [8]. Antimicrobial photodynamic therapy (aPDT) works on application of a photosensitizer, light sources, and oxygen to trigger bacterial destruction. The light source will irradiate the target infection that has been applied with a photosensitizer to produce singlet oxygen and free radicals that cause bacterial cell damage [9].

PDT in endodontic therapy has been tested using different combinations of photosensitizers and light sources, which showed different results. Photosensitizers used in PDT techniques must be nontoxic and effectively absorb light of the appropriate wavelength to produce optimal antimicrobial activity. One of the recently developed photosensitizers is curcumin [8] . Curcumin is a good antibacterial agent and can be used as a photosensitizer in treating pathogenic microbes in the oral cavity. In addition, several studies show that curcumin has photokilling and photobiological abilities so it can be applied as a promising photosensitizer for PDT [10].

2. Material and methods

2.1. Search Strategy

The scoping review was conducted through a literature search in electronic databases including PUBMED, ScienceDirect, and MDPI. Boolean operators (OR and AND) were utilized with the keywords "LED-Curing Light," "photodynamic therapy," "curcumin," and "root canal treatment," focusing on publications from 2019 to 2024.

2.2. Inclusion and Exclusion Criteria

The experimental literature review, written in English, compares the effectiveness of Cur-aPDT with conventional disinfection methods, focusing on bacterial viability parameters in infected root canals.

The exclusion criteria for this review include literature utilizing non-experimental methods (such as questionnaire-based research, opinions, literature reviews, cross-sectional studies, cohort studies, dissertations, theses, and case studies), studies with irrelevant titles and abstracts, and studies that do not compare the effectiveness of Cur-aPDT with conventional disinfection methods.

2.3. Selection Process

A thorough search in three electronic databases initially found 186 articles. After eliminating 98 studies that were not freely accessible, 74 more were excluded based on the set criteria. Out of the 88 articles evaluated, 8 did not meet the inclusion criteria and were removed. This left 6 articles for qualitative analysis.

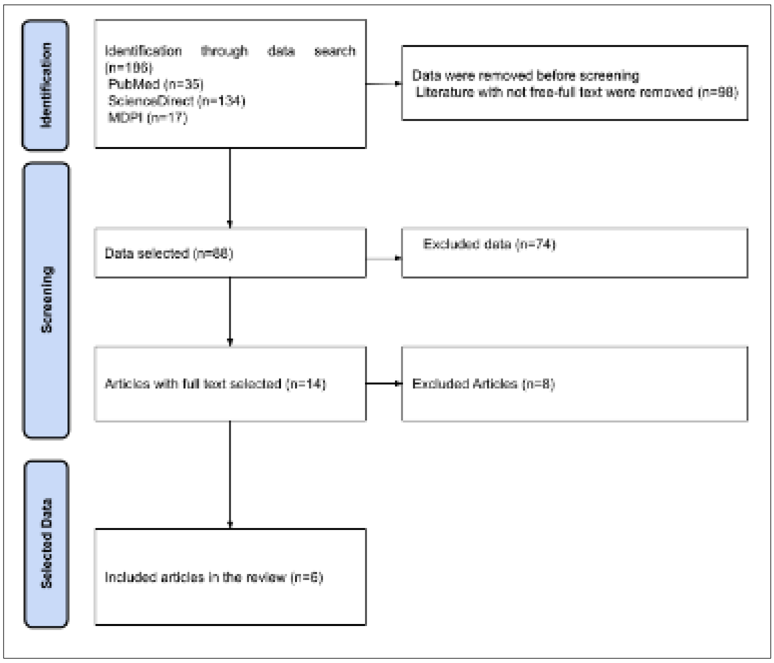

Figure 1 PRISMA Flowchart

3. Results and discussion

Table 1 Selection Results of Articles Covering Photodynamic Therapy Using Curcumin (CUR-aPDT) on RCT

Author	Study Design	Result
Strazzi-Sahyon, et al. (2022) [11]	Experimental Study	The PDT + C1000 group exhibited no cell viability (p<0.05). Laser-activated curcumin at 1000 mg/L inhibited the viability of L-929 fibroblasts. In contrast, curcumin activated by laser at 500 mg/L did not significantly affect the viability of L-929 fibroblast cells under in vitro conditions.
Moradi, et al. (2022) [12]	Experimental Study	Groups treated with aPDT with C+LED (P = 0.005) and riboflavin + LED (P = 0.011) showed a significant reduction in colony numbers in one third of the extracted tooth root canals (P < 0.05), suggesting their potential as effective supplementary or alternative root canal disinfection methods.
Sharifzadeh, et al. (2024) [13]	Experimental Study	The average penetration depth was greatest for curcumin, followed by methylene blue and indocyanine green, with significant differences among all three groups (P<0.05). Curcumin exhibited the highest penetration rate, particularly in the coronal region compared to the middle and apical regions, making it effective for root canal disinfection in endodontic treatment.
Oda, et al. (2022) [14]	Experimental Study	A significant reduction in bacterial viability (P < 0.05) was observed in the following order: positive control < LED light curing alone < curcumin alone < curcumin + LED light curing = standard PDT.
Minhaco, et al. (2023) [15]	Experimental Study	Curcumin demonstrated strong antimicrobial activity when activated by blue LED light, particularly against multispecies biofilms, as shown by a 3.37 log reduction in the viability of biofilms formed in dentinal tubules compared to the untreated group (p<0.0001).
Ensafi, et al. (2022) [16]	Experimental Study	Nano-curcumin combined with LED and SWEEPS exhibited the greatest antibacterial effect, significantly reducing the number of Enterococcus faecalis bacterial colonies compared to the LED alone group.

Various techniques developed for root canal disinfection, including aPDT, can increase the efficacy of RCT [17]. Photodynamic LED activates curcumin as a photosensitizer (PS) agent to affect cell viability, membrane permeability, and intracellular ROS of pathogenic bacteria, especially *Enterococcus faecalis* [18]. The mechanism of aPDT is divided into Type I and Type II. Type 1: Light-excited PS interacts with surrounding molecules through exchange of electrons and hydrogen atoms resulting in environmental changes. Upon activation of the PS, oxygen ions and free radicals are released, which kill the targeted cells. In Type II reactions, the PS is activated by LEDs and interacts with ground-state molecular oxygen, creating excited singlet-state oxygen ($^1O_2$) that directly attacks the target cells. These reactions can occur simultaneously [19].

The potential of curcumin as PS is known because it has an absorption band between 400-500 nm, with a maximum peak at 430nm Curcumin has antimicrobial effects against bacteria, viruses, and fungi [14]. Curcumin has the highest penetration depth and is suitable as root canal disinfection in endodontic treatment, which has a greater average (3000 µm) than methylene blue (MB), which is then followed by indocyanine green (ICG) [13].

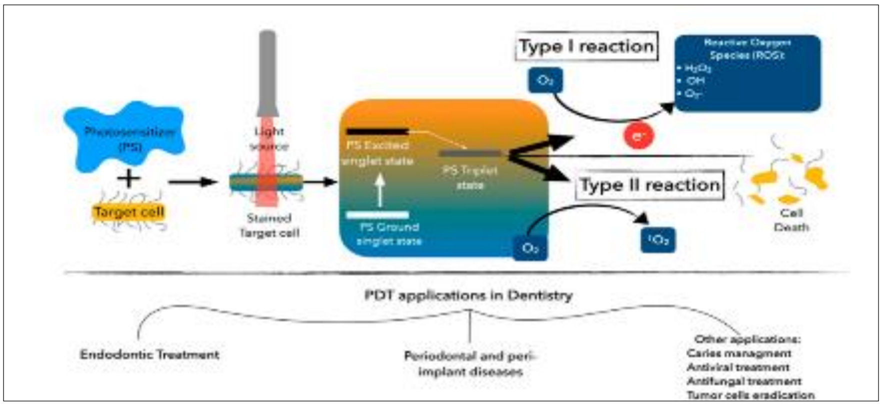

Figure 2 PDT mechanism and practical application in dentistry [20]

An in vitro study by Strazzi-Sahyon et al. (2022) compared the bacterial viability of PDT and NaOCl at various concentrations. The findings revealed that aPDT with 1000 mg/L curcumin showed no cell viability and significantly higher cytotoxicity compared to 2.5% NaOCl [11]. Moradi et al. (2022) assessed the antibacterial activity of aPDT using curcumin, riboflavin, and NaOCl on *Enterococcus faecalis* biofilms by counting bacterial colonies in the coronal, middle, and apical sections. The study found a significant reduction in colony counts with aPDT using curcumin compared to NaOCl, primarily due to the difficulty in accessing the apical third, which necessitates chemical root canal cleaning along with conventional irrigation methods [12].

A study by Minhaco et al. (2023) investigated the antimicrobial activity of curcumin-loaded nanoparticles as a photosensitizer for photodynamic therapy (PDT) using LED light. The antimicrobial activity was assessed using MIC, MBC, and the effect of PLGA nanoparticles loaded with curcumin (NP + Cur) on single and multispecies biofilms in dentinal tubules. The study showed that incorporating curcumin into nanoparticles enhanced its antimicrobial activity. Curcumin has strong potential as a photosensitizer because it can bind to bacterial lipid and protein membranes, absorb blue light, and produce reactive oxygen species.

A study by Ensafi et al. (2022) found that using curcumin and nano-curcumin alone, or combined with LEDs and the SWEEPS technique, significantly reduced the number of *Enterococcus faecalis* colonies compared to the control group. Curcumin and nano-curcumin can penetrate *Enterococcus faecalis* biofilms and degrade them by breaking down the exopolysaccharide matrix. The enhanced antimicrobial activity of LEDs combined with SWEEPS is attributed to the distinct and incoherent nature of LED light, which irradiates microbial cells from all directions during aPDT. This causes damage to the cell membrane and allows light to penetrate the microbial cells.

4. Conclusion

Antimicrobial photodynamic therapy (Cur-aPDT) using curcumin as a root canal disinfectant can be an effective alternative to conventional methods. It can enhance the success of root canal treatment by affecting the cell viability of pathogenic bacteria, such as *Enterococcus faecalis*, through the production of reactive oxygen species (ROS).

Compliance with ethical standards

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Disclosure of conflict of interest

All authors declare that there are no conflicts of interest regarding the publication of this document.

References

[1] Tong J, Liu L, Du J, Gao Y, Song D, Huang D. Effect of photon-induced photoacoustic streaming and shock-wave enhanced emission photoacoustic streaming technique on the removal of the smear layer after root canal preparation in curved root canals. J Dent Sci [Internet]. 2023;18(1):157–64.

[2] Stefani R. Perawatan saluran akar satu kali kunjungan dilanjutkan dengan restorasi endocrown. J Kedokt Gigi Terpadu. 2023;5(1):16–9.

[3] Jezeršek M, Jereb T, Lukač N, Tenyi A, Lukač M, Fidler A. Evaluation of Apical Extrusion During Novel Er:YAG Laser-Activated Irrigation Modality. Photobiomodulation, Photomedicine, Laser Surg. 2019;37(9):544–50.

[4] Kadić S, Baraba A, Miletić I, Ionescu AC, Brambilla E, Ivanišević Malčić A, et al. Influence of different laser-assisted retrograde cavity preparation techniques on bond strength of bioceramic-based material to root dentine. Lasers Med Sci. 2020;35(1):173–9.

[5] Vatanpour M, Toursavadkouhi S, Sajjad S. Comparison of three irrigation methods: SWEEPS, ultrasonic, and traditional irrigation, in smear layer and debris removal abilities in the root canal, beyond the fractured instrument. Photodiagnosis Photodyn Ther [Internet]. 2022;37(4):102707.

[6] Alghamdi F, Shakir M. The Influence of *Enterococcus faecalis* as a Dental Root Canal Pathogen on Endodontic Treatment: A Systematic Review. Cureus. 2020;12(3):1–10.

[7] Wong J, Manoil D, Näsman P, Belibasakis GN. Microbiological Aspects of Root Canal Infections and Disinfection Strategies : An Update Review on the Current Knowledge and Challenges. 2021;2(June).

[8] Plotino G, Grande NM, Mercade M. Photodynamic therapy in endodontics. Int Endod J. 2019;52(6):760–74.

[9] Chiniforush N, Pourhajibagher M, Shahabi S, Kosarieh E, Bahador A. Can antimicrobial photodynamic therapy (aPDT) enhance the endodontic treatment? J Lasers Med Sci [Internet]. 2016;7(2):76–85.

[10] Kah G, Chandran R, Abrahamse H. Curcumin a Natural Phenol and Its Therapeutic Role in Cancer and Photodynamic Therapy: A Review. Pharmaceutics. 2023;15(2).

[11] Strazzi-Sahyon HB, Cintra LTA, Nakao JM, Takamiya AS, Queiroz IOA, Dos Santos PH, et al. Cytotoxicity of root canal irrigating solutions and photodynamic therapy using curcumin photosensitizer. Photodiagnosis Photodyn Ther [Internet]. 2022;38(January):102795.

[12] Moradi M, Fazlyab M, Pourhajibagher M, Chiniforush N. Antimicrobial action of photodynamic therapy on *Enterococcus faecalis* biofilm using curing light, curcumin and riboflavin. Aust Endod J. 2022;48(2):274–82.

[13] Sharifzadeh SS, Amin MG, Ghadim NM, Fazlyab M, Azizi A, Medicine M, et al. Comparative Analysis of Photosensitizer Penetration Depth in Root Canal Debridement for Endodontic Disinfection. 2024;19(1):35–8.

[14] Oda, D. F., Duarte, M. A. H., Andrade, F. B. D., Moriyama, L. T., Bagnato, V. S., & de Moraes, I. G. Antimicrobial action of photodynamic therapy in root canals using LED curing light, curcumin and carbopol gel. International endodontic journal.2019;52(7):1010-1019.

[15] Minhaco VMTR, Maquera Huacho PM, Mancim Imbriani MJ, Tonon CC, Chorilli M, Rastelli AN de S, et al. Improving antimicrobial activity against endodontic biofilm after exposure to blue light-activated novel curcumin nanoparticle. Photodiagnosis Photodyn Ther [Internet]. 2023;42(February):103322.

[16] Ensafi F, Fazlyab M, Chiniforush N, Akhavan H. Photodiagnosis and Photodynamic Therapy Comparative effects of SWEEPS technique and antimicrobial photodynamic therapy by using curcumin and nano-curcumin on *Enterococcus faecalis* biofilm in root canal treatment. Photodiagnosis Photodyn Ther [Internet]. 2022;40(July):103130.

[17] Chiniforush N, Pourhajibagher M, Shahabi S, Kosarieh E, Bahador A. Can antimicrobial photodynamic therapy (aPDT) enhance the endodontic treatment? J Lasers Med Sci [Internet]. 2016;7(2):76–85.

[18] Pourhajibagher M, Chiniforush N, Parker S, Shahabi S, Ghorbanzadeh R, Kharazifard MJ, et al. Evaluation of antimicrobial photodynamic therapy with indocyanine green and curcumin on human gingival fibroblast cells: An in vitro photocytotoxicity investigation. Photodiagnosis Photodyn Ther. 2016;15:13–8.

[19] Alfirdous RA, Garcia IM, Balhaddad AA, Collares FM, Martinho FC, Melo MAS. Advancing photodynamic therapy for endodontic disinfection with nanoparticles: Present evidence and upcoming approaches. Appl Sci. 2021;11(11):1–20.

[20] Abdelkarim-Elafifi H, Parada-Avendaño I, Arnabat-Dominguez J. Photodynamic therapy in endodontics: A helpful tool to combat antibiotic resistance? a literature review. Antibiotics. 2021;10(9):1–11.