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Derleme/Review Article

Phytotherapeutic Irrigation Agents in Primary Tooth Root Canal Treatment

Süt Diş Kanal Tedavisinde Fitoterapötik İrigasyon Ajanları

İsmail CİHANGİR[1]

[1] *Yozgat Bozok Üniversitesi Diş Hekimliği Fakültesi, Çocuk Diş Hekimliği Anabilim Dalı, Türkiye*

ABSTRACT: It is important in pediatric dentistry that baby teeth remain in the mouth until permanent teeth erupt. When cavities are left untreated, irreversible pulpitis develops due to advancing infection, requiring root canal treatment or extraction. Root canal treatment is a priority due to the aesthetic, speech, chewing, and space-maintaining functions of primary teeth. Mechanical preparation alone is insufficient in root canal treatment; it must be supported by chemical irrigation. Chemical irrigation agents affect the compliance level of pediatric patients due to their unpleasant taste and odor. In addition, the toxic effect they create in the periapical tissues can cause adverse effects on the permanent tooth germs located under the primary teeth. For this reason, there is growing interest in plant-based irrigation agents in pediatric dentistry. This review focuses on the antimicrobial properties, clinical applicability, and current limitations of phytotherapeutic irrigation agents proposed for use in primary tooth root canal treatment.

Keywords: Root canal treatment, chitosan, papain, green tea

ÖZET: Pediatrik diş hekimliğinde süt dişlerinin daimi dişler sürünceye kadar ağızda kalması önemlidir. Çürükler tedavi edilmediğinde ilerleyen enfeksiyona bağlı olarak geri dönüşümsüz pulpitis gelişir ve kanal tedavisi veya çekim gereksinimi ortaya çıkar. Süt dişlerinin estetik, konuşma, çiğneme ve yer tutuculuk işlevleri nedeniyle kanal tedavisi öncelikli bir seçenektir. Kanal tedavisinde yalnızca mekanik preparasyon yeterli değildir; kimyasal irrigasyonla desteklenmelidir. Kimyasal irrigasyon ajanlarının hoş olmayan tat ve kokuları çocuk hastaların uyumunu etkileyebilir. Ayrıca periapikal dokularda oluşturabilecekleri toksik etkiler, süt dişlerinin altında bulunan daimi diş germleri üzerinde olumsuz etkilere yol açabilir. Bu nedenle pediatrik diş hekimliğinde bitki temelli irrigasyon ajanlarına ilgi artmaktadır. Bu derleme, süt dişi kanal tedavisinde kullanımı önerilen fitoterapötik irrigasyon ajanlarının antimikrobiyal özelliklerine, klinik uygulanabilirliğine ve mevcut sınırlılıklarına odaklanmaktadır.

Anahtar kelimeler: Kitosan, kök kanal tedavisi, papain

Sorumlu Yazar: Öğr. Gör. İsmail Cihangir, e-posta: ismail.cihangir@bozok.edu.tr

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INTRODUCTION

Early childhood caries is a preventable infectious disease with a high prevalence. It is a significant public health problem in both developed and developing countries. Numerous factors related to microbiology, nutrition, and oral hygiene contribute to the disease. (1,2,3) Dental caries ranks among the leading childhood diseases in terms of severity and prevalence. (4) Cavities in the primary dentition are also indicative of the risk of permanent tooth decay. If cavities are left untreated, problems such as early primary tooth loss, malocclusion, growth and development delays, nutritional deficiencies, speech problems, rampant caries, pain, inflammation, and abscesses may occur. (5)

Root canal treatment or extraction is required to treat irreversible pulpitis in primary teeth. Root canal treatment is an alternative treatment protocol to extraction. The success rate of primary tooth root canal treatment has been reported to be between 68% and 100%. (4, 5, 6) Effective removal of bacteria and their byproducts from root canals is crucial for the success of root canal treatment. Mechanical procedures alone are insufficient for cleaning root canals. Bacteria and their byproducts can only be removed from difficult-to-clean areas such as the isthmus, root bifurcations, and lateral and accessory canals connected to the main canal through irrigation solutions. A study has shown that regardless of the preparation technique used, canal files cannot clean 35% of the canal by making contact with it.(4,6)

During canal shaping, a layer called smear forms, which is irregular and amorphous in structure and contains organic and inorganic content derived from pulp and dentin. The advantages and disadvantages of the smear layer are still debated. Some researchers have stated that it acts as a barrier, preventing bacteria from adhering to the dentin tubules. The disadvantages of the smear layer include its content of bacteria and necrotic tissue, which increases microleakage by preventing penetration between the filling material and the dentin. It has been reported that removal of the smear layer from the root canals is necessary for successful root canal treatment. (2,5)

Irrigation agents are materials proven to be essential in root canal treatment due to their effects such as ensuring disinfection of the root canal, acting as a lubricant for mechanical procedures, and facilitating the removal of organic and inorganic content from the canal system. (6) The most commonly used irrigation solutions in root canal treatment are sodium hypochlorite, ethylenediaminetetraacetic acid, chlorhexidine, MTAD, TetraClean, hydrogen peroxide, and calcium hydroxide. (4,5)

In recent years, increasing attention has been directed toward phytotherapeutic products in dentistry due to their favorable biocompatibility profiles and reduced cytotoxic effects compared to conventional chemical agents. This interest is particularly relevant in pediatric dentistry, where safety considerations are of paramount importance.

Content And Purpose Of The Review

The use of natural materials is becoming increasingly widespread in medical practices and dentistry due to their non-

Sorumlu Yazar: Öğr. Gör. İsmail Cihangir, e-posta: ismail.cihangir@bozok.edu.tr

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toxic and safe content. The use of chemical irrigation agents in primary teeth is even more risky in pediatric patients due to the possibility of apical migration affecting the permanent tooth germ. The presence of natural physiological resorption processes in primary teeth and the unpleasant taste of these agents have increased interest in natural molecules with biocompatibility and low toxicity properties in pediatric dentistry. Due to their broad-spectrum antibacterial properties and effects such as preventing bacterial colonization, they are considered to be potential alternatives to existing irrigation solutions. The aim of this review is to examine phytotherapeutic irrigation agents with promising potential in primary tooth root canal treatment and related studies.

Green Tea

Green tea has a broad antibacterial effect; it is effective against acids produced by bacteria in plaque. It has thermogenic, probiotic, and antimicrobial properties that prevent biofilm formation. Furthermore, the fluoride it contains is effective in providing anti-plaque and chelation properties. (7) Studies have reported that, thanks to the hydroxyl radicals it produces, it has a strong antibacterial effect against E. faecalis and can kill 100% of the bacteria in as little as 6 minutes. (8) In addition to its antibacterial activity, green tea contains polyphenolic compounds such as catechins that exhibit antioxidant and anti-inflammatory properties. These compounds may contribute to reduced oxidative stress within the root canal system. However, the lack of tissue-dissolving capacity and limited clinical evidence restrict its use as a sole phytotherapeutic irrigation agent.

Ramezanali et al. (9) compared the antibacterial effect of green tea extract and a 2.5% sodium hypochlorite solution against E. faecalis. Although green tea caused a significant decrease in the number of bacterial colonies, it was not as effective as sodium hypochlorite. Furthermore, there is insufficient evidence regarding the antibacterial effect of green tea, and further studies are needed. Mohammed et al. (10) reported that green tea showed the highest antibacterial activity against Enterococcus faecalis among the tested herbal irrigation solutions and exhibited comparable efficacy to sodium hypochlorite.

In primary teeth, the low cytotoxicity and mild taste of green tea may be advantageous for pediatric patient cooperation; however, its limited tissue-dissolving capacity may restrict its effectiveness in root canals with extensive necrotic tissue. (8-10)

Noni (Morinda Citrifolia)

Indian gooseberry is a plant-based ingredient that has been used for many years in various fields such as cancer, diabetes, blood pressure, and pain control. Thanks to its components, it has been found to be effective against bacterial strains such as Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus subtilis, Proteus morganii, Escherichia coli, Salmonella, and Shigella. (11,12) The antibacterial activity of Morinda citrifolia is mainly attributed to its bioactive components, including anthraquinones and phenolic compounds. Its relatively low cytotoxicity suggests potential clinical safety in pediatric applications. Nevertheless, its antibacterial efficacy appears to be inferior to conventional chemical irrigants. (12)

Sorumlu Yazar: Öğr. Gör. İsmail Cihangir, e-posta: ismail.cihangir@bozok.edu.tr

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Jose et al. (11) evaluated the antibacterial activity of Indian mulberry and sodium hypochlorite against E. faecalis and found that Indian mulberry extract showed less toxic properties on surrounding tissues but had less antibacterial activity against E. faecalis. Boel and Dennis (12) reported that ethanolic extract of Morinda citrifolia (noni) exhibited antibacterial activity against Fusobacterium nucleatum in an in vitro study, with a minimum inhibitory concentration of 12.5% and a minimum bactericidal concentration of 25%.

Considering the close proximity of the permanent tooth germ in primary teeth, the relatively low toxicity of Morinda citrifolia may represent a potential advantage; nevertheless, its antimicrobial efficacy may be insufficient as a sole irrigant in primary root canals. (11,12)

Propolis

Propolis is a brown resin mixture collected by honeybees from various plant extracts, possessing antibacterial, antifungal, anti-inflammatory, antioxidant, anesthetic, and cytotoxic properties. (13) Propolis has been shown to inhibit the F-ATPase activity of S. mutans and reduce acid production. Furthermore, its antibacterial activity against anaerobic bacteria such as Prevotella nigrescens, Fusobacterium nucleatum, and E. faecalis has been reported. (14) Propolis exerts its antimicrobial effects by disrupting bacterial cell walls and inhibiting enzymatic activity. Its anti-inflammatory and antioxidant properties may provide additional benefits in endodontic treatment. However, variability in its chemical composition depending on geographic origin may influence its clinical effectiveness. (13,14)

Oncag et al. (15) observed that propolis successfully exhibited antibacterial activity against E. faecalis in root canals. Nara et al. (16) compared the antibacterial efficacy of sodium hypochlorite, propolis, and MTAD. The study found that propolis was less effective than the other solutions in eliminating bacteria. (16) İlkgelen and Iriboz (17) reported that propolis used as an irrigation solution influenced the push-out bond strength of root canal sealers, showing mixed failure patterns particularly with bioceramic sealers in an in vitro study. Barros et al. (18) demonstrated that ultrasonically activated propolis was effective in reducing Fusobacterium nucleatum and endotoxin levels, with efficacy comparable to sodium hypochlorite.

In primary teeth, the anti-inflammatory properties of propolis may support periapical tissue healing; however, variability in its composition and taste may limit its routine clinical use in pediatric endodontics. (13-17)

Azadirachta Indica (Neem, Indian Lilac)

Azadirachta Indica, known as Indian lilac, is a plant extract used in medical applications for its antibacterial, antiviral, antioxidant, and hemostatic properties. It has been reported to inhibit bacterial adhesion and colonization in the root canals of neem. In a study comparing it with sodium hypochlorite and chlorhexidine, it showed similar antibacterial efficacy. (19) The antimicrobial activity of neem is associated with bioactive compounds such as nimbin, nimbidin, and azadirachtin. Neem has been reported to inhibit bacterial adhesion and biofilm formation. Despite these advantages, its antibacterial efficacy

Sorumlu Yazar: Öğr. Gör. İsmail Cihangir, e-posta: ismail.cihangir@bozok.edu.tr

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in root canal disinfection remains lower than sodium hypochlorite in most studies. (19,20)

Panchal et al. (20) compared the antibacterial effect of neem and sodium hypochlorite on E. faecalis. It was shown that the reduction in colony count by neem extract was insufficient compared to sodium hypochlorite. Meyappan et al. (21) reported that a mixture of Azadirachta indica demonstrated effective smear layer removal, although its efficacy was lower than MTAD and QMix in an in vitro study.

The biocompatibility of neem may be beneficial in primary teeth undergoing physiological root resorption, yet current evidence suggests that its antibacterial effect is inferior to conventional irrigants in primary tooth root canal disinfection. (19-21)

Triphala

Triphala is a natural formulation consisting of a blend of three different plants (Emblica officinalis, Terminalia bellirica, Terminalia chebula) that possesses bacteriostatic and bactericidal effects due to its tannic acid content. With its antioxidant and anti-inflammatory properties, it has been reported to provide a high success rate against E. faecalis strains in as little as 6 minutes when used as a root canal irrigation agent. (22) Triphala exhibits antimicrobial activity primarily due to its high tannin and polyphenol content. Its antioxidant properties may support anti-inflammatory effects within the root canal environment. However, evidence regarding its clinical effectiveness is predominantly limited to in vitro studies. (22,23)

Pujar et al. (23) compared the antibacterial efficacy of triphala and green tea with sodium hypochlorite, and found that sodium hypochlorite eliminated all E. faecalis colonization. Jain et al. (24) in an ex vivo study evaluating the antimicrobial efficacy of various phytotherapeutic irrigation solutions, reported that Triphala exhibited the highest antibacterial activity against Enterococcus faecalis compared to propolis, neem, green tea.

In the context of primary teeth, the antioxidant properties of triphala may contribute to reduced inflammatory responses, although the absence of clinical studies limits its applicability in pediatric endodontic practice. (22-24)

Apple Cider Vinegar

Apple cider vinegar is one of the herbal products considered for use as an irrigation agent in root canal treatment due to its antiseptic properties. It has demonstrated bactericidal effects against E. faecalis and S. aureus. (25) The antibacterial properties of apple cider vinegar are mainly attributed to its acidic nature and organic acid content. It has also been reported to possess smear layer removal capability. However, its low pH may raise concerns regarding potential dentin erosion if used without proper dilution. (25,26)

Morgental et al. (26) evaluated the antibacterial efficacy of various irrigation solutions (sodium hypochlorite, apple cider vinegar, chlorhexidine, and saline) against E. faecalis and found that the use of apple cider vinegar in combination with sodium hypochlorite resulted in a significant decrease in bacterial colony count.

Sorumlu Yazar: Öğr. Gör. İsmail Cihangir, e-posta: ismail.cihangir@bozok.edu.tr

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However, apple cider vinegar alone did not show sufficient antibacterial activity.

In primary teeth, concerns regarding dentin erosion due to acidic pH should be carefully considered, particularly in teeth with thin dentinal walls and ongoing root resorption.

Papain

Papain is a plant-based agent produced from the fruit and leaves of the papaya plant, which grows in tropical regions. It is a chloramine-containing endoprotein with bactericidal, bacteriostatic, and anti-inflammatory effects. It is used in the food, technology, pharmaceutical, and cosmetic industries and has properties similar to human pepsin. The chlorine and ammonia it contains provide the bactericidal effect, while toluidine blue and salts provide the disinfectant effect. (27) Papain is widely used in the treatment of skin lesions. It is reported to be effective in cleaning necrotic tissue and accelerating the tissue healing process. In dentistry, it is used in the treatment of oral ulcers, promoting periodontal healing, and cleaning organic residues prior to the application of pit-fissure sealants. Papain is also found as an abrasive in toothpastes. (28)

The primary use of papain in dentistry is to mechanically remove infected dentin. It can affect both gram-negative and gram-positive bacteria. Papacaire, Cariecare, Biosolv, and Brix 3000 are agents containing papain. Due to the antibacterial properties of papain-containing agents, their use as irrigation solutions in root canals has begun to be investigated. Therefore, the effectiveness of papain and papain-containing agents in root canals has been evaluated in various studies. (29,30) Papain functions as a proteolytic enzyme capable of degrading necrotic tissue and organic debris. Its anti-inflammatory and antimicrobial properties may facilitate canal debridement in primary teeth. Nevertheless, its antibacterial efficacy remains lower than that of sodium hypochlorite when used alone. (28-30)

Maru et al. (29) compared the antibacterial efficacy of Papacaire and Carisolv, which are used as irrigation solutions in root canal treatment. After irrigation, Papacaire resulted in a significant reduction in bacterial load compared to Carisolv, which contains sodium hypochlorite. Kilani et al. (30) reported that papain, used as an irrigation solution, was more effective than saline. However, its antibacterial effect was found to be insufficient compared to sodium hypochlorite.

Papain may be particularly suitable for use in primary teeth due to its enzymatic action and gentle tissue-debriding effect; however, its antimicrobial efficacy alone may not be sufficient for complete canal disinfection. (27-30)

Chitosan

Chitosan (β (1,4) D-glucosamine) is a positively charged, hydrophilic biopolymer derived from chitin found in shrimp, crab, and occasionally mushroom shells. It exists in various forms, including beads, powder, flakes, film, hydrogel, and nanoparticles. Chitosan is easily soluble in acidic environments but cannot dissolve at pH values higher than 6.5 due to the amino group it contains. (31) It is highly biocompatible. It possesses biological

Sorumlu Yazar: Öğr. Gör. İsmail Cihangir, e-posta: ismail.cihangir@bozok.edu.tr

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adhesion and degradability properties and has no proven toxicity. Chitosan particles easily interact with the negatively charged bacterial surface due to their positive charge structure and large surface area. In this way, it increases the permeability of the bacterial surface structure, allowing intracellular components to leak out and causing cell death. The literature reports that the chitosan molecule has antibacterial and antifungal activity. Thanks to its broad-spectrum antimicrobial properties, it has various applications in dentistry. Chitosan exhibits broad and effective antimicrobial activity against bacteria, viruses, and fungi. It has been observed to be particularly effective against gram-positive bacteria. Due to its antibacterial effect, its use as an irrigation solution in root canals has been evaluated. (32,33)

Chitosan exhibits antimicrobial activity through electrostatic interactions between its positively charged molecules and negatively charged bacterial cell membranes, leading to increased membrane permeability. It has also been reported to possess chelating properties that may support smear layer removal. Despite promising results, standardized clinical protocols for its use are still lacking. (31-33) Kadour et al. (34) reported that sodium hypochlorite and chitosan solution were effective against E. faecalis colonies. The antibacterial efficacy of chitosan was found to be as successful as sodium hypochlorite. Kaur et al. (35) demonstrated that the use of chitosan in root canals significantly eliminated E. faecalis.

The successful results of chitosan's antibacterial efficacy in the literature offer hope in the search for an alternative irrigation solution to sodium hypochlorite. In primary teeth, the biocompatibility and antibacterial properties of chitosan may be advantageous in minimizing potential adverse effects on the developing permanent tooth germ, although standardized pediatric protocols are still lacking. (34,35)

CONCLUSION

Sodium hypochlorite and other chemical agents used as the gold standard in root canal treatment have a high success rate. However, their unpleasant taste and odor in pediatric patients affect treatment compliance. Furthermore, since permanent tooth germs are located immediately beneath the deciduous teeth, the toxic properties of these agents bring certain disadvantages. The use of plant-based root canal irrigation solutions, either in combination or by isolating the active components of the plant, holds promise for the future.

Phytotherapeutic irrigation agents have gained increasing interest in pediatric dentistry due to their antimicrobial properties and favorable biocompatibility. Although conventional chemical agents remain the gold standard, phytotherapeutic alternatives may offer advantages in primary teeth. However, current evidence is largely based on in vitro studies, and further clinical research is required before routine clinical use can be recommended.

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Sorumlu Yazar: Öğr. Gör. İsmail Cihangir, e-posta: ismail.cihangir@bozok.edu.tr

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