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Phytotherapy: A Complementary Approach in Endodontic Management

Mayada Jemâa[1,*], Dhiaedddine Shili[2], Sabrine Touaiti[3] and MB Khattech[4]

[1]Department of Dental Medicine, Military Principal Hospital of Instruction, Oral Health and oro- facial Rehabilitation laboratory research (LR12ES11), Faculty of Dental Medicine, University of Monastir, Avicenne Avenue, Monastir 5000, Tunisia
[2]Department of Dental Medicine, Military Principal Hospital of Instruction, Laboratory of Dento-Facial Clinical and Biological Approach (ABCDF) LR12ES10, Faculty of Dental Medicine, University of Monastir, Avicenne Avenue, Monastir 5000, Tunisia
[3]Dentist, private practice, Tunis, Tunisia
[4]Department of Dental Medicine, Military Principal Hospital of Instruction, Oral Diseases in the military UR17DN04, Faculty of Dental Medicine, University of Monastir, Avicenne Avenue, Monastir 5000, Tunisia

[*]**Corresponding Author:** Mayada Jemâa, Associate Professor, Department of Dental Medicine, Military Principal Hospital of Instruction, Oral Health and oro- facial Rehabilitation laboratory research (LR12ES11), Faculty of Dental Medicine, University of Monastir, Avicenne Avenue, Monastir 5000, Tunisia, Tel.: +21696888820, E-mail: dr.jemaamayada@gmail.com

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Abstract

The use of plant-derived products for medicinal purposes, known as phytotherapy, is gaining increasing interest as a complementary approach to traditional protocols in endodontics. This literature review examines the various clinical applications of phytotherapy in endodontics, with a particular focus on its potential utility in all stages of conservative or surgical endodontic management. This analysis draws upon in vivo and in vitro data to examine the specific indications of phytotherapy, with a particular focus on its advantages in terms of antimicrobial, anti-inflammatory, and regenerative activity. As a supplementary approach, phytotherapy offers a natural and promising alternative to enhance the outcomes of endodontic treatments, while providing a sustainable perspective on oral healthcare.

Keywords: Endodontics, Phytotherapy; Herbal products; Herbal medicine; Natural products; E. faecalis, Intracanal medicaments; Irrigants

Introduction

Phytotherapy represents a relatively recent development in the field of medicine, offering a potential complement to conventional endodontic therapies. Rather than supplanting existing techniques, it augments them with the therapeutic advantages of plant extracts.Some conventional endodontic products may have adverse effects such as tissue toxicity, allergic potential and microbial resistance. Therefore, researchers are increasingly interested in plant protection products with different application potentials in endodontics. Phytotherapy involves the combination of organic substances with conventional drugs with the aim of reducing inflammation, controlling infections, and enhancing pain relief during endodontic operations.

Phytotherapy is not intended to replace existing dental practices, but rather to complement them. This enables practitioners to tailor treatments more effectively and to attend more fully to the individual needs of each patient. Indeed, herbal alternatives could be employed as pulp capping or pulpotomy materials, endodontic irrigants, intracanal medication, preservation media of permanent teeth avulsed following trauma, and also as sealing materials during root canal filling or in endodontic retreatment. In addition, studies evaluating the use of phytotherapy in bone and endodontic regeneration are promising.

The potential of herbal products for endodontic applications must be evaluated in terms of their antibacterial activity against relevant pathogens and their cytocompatibility with human cells. The antibacterial activity is evaluated through the use of microbial cultures. This involves the measurement of bacterial growth inhibition, which is achieved through techniques such as the Minimum Inhibitory Concentration (MIC), Minimum Bactericidal Concentration (MBC) and the zone of inhibition assay. The cytocompatibility was evaluated through the use of cell culture models or cytotoxicity assays.

There is a paucity of literature on the potential side effects of herbal products. Consequently, further research is required utilising current methodologies and techniques of the highest scientific quality to evaluate biocompatibility, efficacy, the risk of tooth discolouration with extended use and potential interactions with other products.The objective of this paper is to examine the ways in which phytotherapy can enhance endodontic care, with a particular focus on the advantages of this additional tool for practitioners, while maintaining established practices.

Definition

Phytotherapy, also known as herbal medicine or botanical medicine, is a medical procedure that employs natural substances and plant-based extracts to treat, prevent, or manage a range of medical conditions.The methodical application of plants or plant extracts that include chemicals with established pharmacological qualities that are biologically active, such as terpenes, flavonoids, and alkaloids, is a key aspect of this process. These natural ingredients, which are available in a variety of dosage forms, including extracts, infusions, and capsules, are believed to have therapeutic effects due to their biochemical interactions with the human body. One common explanation for the effectiveness of phytotherapy is the synergistic impact of numerous chemicals found in plants [1, 2, 3].

The Clinical Applications of Phytotherapy in Endodontics

1/ Preservation of Pulp Vitality

Propolis

Herbal products, in particular propolis, have demonstrated potential as viable substitutes for pulp capping among conventional pulp capping materials. With regard to this, propolis in particular has been subjected to extensive research as a plant-based alternative [4]. Propolis is a resinous material gathered by honeybees.

The principal constituents of propolis are resins (40–55%), beeswax (20–35%), fatty acids, aromatic oils (10%), and pollen (5%). Additionally, it contains minerals, vitamins, and flavonoids. Flavonoids have been demonstrated to exhibit antiviral, anticancer, anti-inflammatory, and antioxidant characteristics [5, 6].

Due to its complex nature, propolis cannot be used directly; instead, it must be extracted using an appropriate solvent. Ethanol is frequently employed in published investigations as it can yield a propolis extract with a low wax content and a high concentration of physiologically active chemicals [7].

Propolis is renowned for its immunostimulatory, cariostatic, antibacterial, anti-inflammatory, and antioxidant properties. Furthermore, it facilitates the healing of wounds and the regeneration of tissue [6]. A comparative histological investigation of human pulp after direct pulp capping on thirty-six premolars was conducted by Parolia et al. in 2010, utilising three distinct materials: propolis, mineral trioxide aggregate (MTA), and Dycal® (calcium hydroxide paste). Histological analysis revealed that teeth treated with Dycal® exhibited higher pulp inflammation than those treated with Propolis and MTA on the 15th and 45th days. The findings of the study indicated that propolis exhibited similar characteristics to those of MTA and Dycal® in terms of dentin bridge development [8].

Propolis exerts anti-inflammatory effects, preventing the formation of prostaglandins and enhancing phagocytic activity and cellular immunity. These actions collectively reinforce the immune system (Balata et al., 2018) [9]. It has been demonstrated that propolis may facilitate the production of hard tissue bridges by stimulating a number of enzyme systems, cellular metabolism, circulation, and collagen formation. The presence of flavonoids, arginine, vitamin C, provitamin A and B complexes, and trace minerals including copper, iron, and zinc is responsible for the aforementioned benefits [8].

In 2021, Ahangari et al. conducted a randomised clinical experiment to compare the efficacy of propolis and calcium hydroxide for pulp capping in human teeth. The results demonstrated that propolis produced high-quality dentin with tubules, which may act as a barrier against microbial invasion and prevent pulp injury. In contrast, calcium hydroxide produced low-quality reparative dentin that was similar to osteodentin [10]. In addition to its anti-inflammatory properties, propolis has been shown to have a notable effect in reducing dentin permeability and hypersensitivity. Propolis has the capacity to partially impregnate dentinal tubules, which gives rise to this property [11]. The scientific evidence currently available does not support the assertion that propolis is more effective than other traditional treatments for pulp capping. It is therefore evident that high-level clinical research based on scientific data is required in order to determine this.

The Turmeric (Curcuma Longa)

The active element of the plant is curcumin, a constituent of the Zingiberaceae family. It inhibits the activity of lipoxygenase and cyclooxygenase, thereby producing strong antioxidant and anti-inflammatory effects [12]. Due to its therapeutic properties, Purohit et al (2017) used distilled water and powdered turmeric as a pulpotomy agent on primary teeth in fifty children aged four to nine years, with follow-up every two, four and six months. The clinical and radiological results of turmeric pulpotomy were encouraging, but the authors recommend further research, including histological assessment [13].

Thyme (Thymus Vulgaris)

Thymus vulgaris is a perennial plant native to the Mediterranean. It is cultivated in many countries. A clinical and radiological evaluation of Thymus vulgaris ethanolic extract as a pulpotomy agent in primary molars was conducted by Alolofi et al in 2016. At one, six and twelve months, the study showed a high clinical success rate of 94.1%. Thymol, flavonoids, carvacrol and apigenin - components of the thymus - have antibacterial, anti- inflammatory and haemostatic properties, which have been suggested as the cause of this result [14].

Garlic (Allium Sativum)

The literature indicates that garlic extract has the potential to inhibit Streptococcus mutans strains that are multi- resistant [14]. In 2015, Mohamed et al. conducted a study to compare the effects of Allium sativum oil and formocresol on the pulpal tissue of eighteen premolars following pulpotomy. The authors found that the oil from Allium sativum was biocompatible with human pulpal tissue. For instance, teeth treated with formocresol exhibited persistent inflammation, which ultimately resulted in necrosis. In contrast, oil from Allium sativum demonstrated a high capacity for healing, leaving the remaining pulpal tissue intact and functional [15].

Aloe Vera

Gala-Garcia et al. (2008) demonstrated that the application of Aloe vera to the pulp tissue of rats resulted in the formation of tertiary dentin. The incorporation of a number of bioactive components, including beta-sitosterol, polysaccharides, and glycoproteins, which facilitate angiogenesis, wound healing, and cell proliferation, was employed to elucidate this phenomenon [14]. In canine teeth undergoing partial pulpotomy, the polysaccharide acemannan derived from Aloe vera has demonstrated comparable outcomes to MTA, with the formation of a mineralised bridge with normal pulpal tissue and the absence of pulpal necrosis or inflammation. In contrast, formocresol demonstrated pulp inflammation without the formation of a mineralised bridge [16].

Conversely, acemannan has been subjected to investigation for utilisation as a direct capping material on primary human teeth. Indeed, the natural product in question has been demonstrated to facilitate the growth, differentiation, production of extracellular matrix, and mineralisation of primary human dental pulp cells, thereby stimulating the creation of dentin [17]. In a similar manner, immature permanent teeth treated with direct pulp capping or partial pulpotomy demonstrated ongoing root growth when exposed to acemannan sponges, as evidenced by Tiên Thuy's 2020 study. The authors conclude that acemannan is a promising and inexpensive biomaterial for vital pulp therapy [18].

2/ Endodontic Irrigation

Morinda Citrifolia

The plant is known by a number of commercial names, including "noni" and "Indian mulberry," and is classified as Morinda citrifolia. It was first discovered in Polynesia approximately 2,000 years ago and is currently regarded as a significant popular medicine. Indeed, Morinda citrifolia (MC) is endowed with a plethora of medicinal properties, including immune-stimulating, analgesic, hypotensive, antibacterial, antiviral, antifungal, and anticancer activities [19].

Research has demonstrated that these substances facilitate the combat against pathogenic bacterial strains, including Salmonella, Shigella, Pseudomonas aeruginosa, Proteus morganii, Staphylococcus aureus, Bacillus subtilis, and Escherichia coli [20].

A study by Murray et al. (2008) aimed to assess the efficacy of Morinda citrifolia juice (MCJ) in removing the smear layer from instrumented root canals, in comparison to 6% sodium hypochlorite (NaOCl) and 2% chlorhexidine (CHX). The study revealed that 6% Morinda citrifolia juice was more effective than 2% chlorhexidine and as efficacious as 6% sodium hypochlorite mixed with 17% ethylenediaminetetraacetic acid (EDTA). The in vitro effectiveness of MC when combined with EDTA irrigation is encouraging [19]. However, in comparison to NaOCl, the investigators discovered that MC juice is a biocompatible antioxidant that is less likely to result in significant adverse events for patients [19].

Propolis

Published research indicates that propolis exhibits potent antibacterial and antifungal properties against a diverse range of pathogens, including Fusobacterium nucleatum, Actinomyces naeslundii, Lactobacillus acidophilus, Prevotella oralis, Porphyromonas

gingivalis, Staphylococcus aureus, Escherichia coli, and Candida albicans [9]. In a study conducted by Al-Qathami and Al-Madi (2003), the antimicrobial efficacy of propolis, saline solution, and 2.5% NaOCl as intracanal irrigants was compared. The results demonstrated that propolis exhibited antibacterial activity comparable to that of 2.5% NaOCl [21].

The evidence suggests that propolis is more biocompatible than NaOCl. However, differences in chemical composition, extraction techniques and antibacterial activity assessment methods raise questions about the quality control and batch-to-batch variability for the standardised development of new drugs [23].

Azadirachta Indica (Neem)

Neem, also known as Indian lilac, is a natural medicinal tree indigenous to India.

In 2013, Vinothkumar et al. demonstrated that neem leaf extract exhibited notable antibacterial efficacy against Candida albicans and Enterococcus faecalis when compared to a 5.25% sodium hypochlorite solution [9].

In 2013, Ghonmode et al. conducted another study which demonstrated that neem leaf extract exhibited a considerably higher antibacterial efficacy against E. faecalis compared to 3% NaOCl [24].

The neem leaf extract exerts its effects by modifying the adherence of bacteria to dentin and by inhibiting the cell membrane [25]. Furthermore, Sebatni et al. (2017) observed that the greatest efficacy in removing the smear layer was observed in canals treated with neem leaf extract when comparing the effectiveness of smear layer removal of various plant extracts, namely green tea extract, orange oil, and neem leaf extract, using scanning electron microscopy (SEM) [26].

Triphala

The powdered fruits of three medicinal plants-Terminalia bellerica, Terminalia chebula, and Emblica officinalis—are combined to create Triphala, an Ayurvedic herbal combination. Research has indicated that tannic acid, a primary component of triphala, exhibits both bactericidal and bacteriostatic capabilities against specific Gram-positive and Gram-negative microorganisms. The mechanism of action involves the inhibition of enzymes, cell membrane transport proteins, and microbial adhesins [25]. The capacity of the extract to eliminate the smear layer and its application as a root canal chelator can be attributed to the tannins, quinones, flavonoids, gallic acid, and citric acid it contains [27].

Green Tea (Camellia Sinensis)

Green tea is a beverage that is consumed globally and is derived from the plant Camellia sinensis. In green tea, epigallocatechin-3--gallate (EGCG) is the most prevalent polyphenol [22]. In their 2019 in vitro study, Dadresanfar et al. examined the antibacterial potential of green tea as an endodontic irrigant in root canals infected with E. faecalis, in comparison to 5.25% NaOCl and 2% CHX. The study's findings demonstrated that the number of microorganisms decreased by 100% when NaOCl was used, 98.9% when CHX was used, 81% when 12.5% green tea was used, and 94.8% when 25% green tea was used [28].

Research has demonstrated that EGCG inhibits bacterial DNA gyrase, preventing DNA overwinding and ultimately resulting in bacterial cell death. It also irreversibly disrupts the membranes of both Gram-positive and Gram-negative bacteria. Furthermore, EGCG has been shown to neutralise toxic terminal metabolites from pathogenic bacteria, such as collagenase and protein tyrosine phosphatase, including alkaline phosphatase [22].

The intriguing qualities of green tea, including its accessibility, affordability, extended shelf life, minimal toxicity, and lack of microbiological resistance, have piqued the curiosity of researchers who wish to examine its potential as an endodontic irrigant. However, it appears that further in vivo research is required [28].

Acacia Nilotica Linn (Babool)

Acacia nilotica is a native Egyptian medicinal herb. It has been demonstrated that bacteria are affected by the extract of this plant by the destruction of vital electrolytic and cellular components, including proteins and nucleic acids [25]. In a 2020 study, Gupta et al. compared the antibacterial efficacy of different plant extracts in eliminating Enterococcus faecalis. The findings indicated that 5% sodium hypochlorite (NaOCl) exhibited the most pronounced antibacterial efficacy against E. faecalis, followed by 20% Thymus vulgaris, 12.5% Salvadora persica, 10% Acacia nilotica, 10% Calendula arvensis, and 10% Thymus vulgaris [29].

Garlic (Allium Sativum)

The principal constituent of garlic, allicin, primarily targets the cell wall and membrane of root canal bacteria, causing significant damage. One international unit (IU) of penicillin is equivalent to one milligram (mg) of allicin [27, 30].

A total of 30 patients diagnosed with asymptomatic apical periodontitis were included in a study to compare the antibacterial activity of 1.8% garlic lemon and 3% sodium hypochlorite (NaOCl). The results demonstrated that garlic exhibited a comparable reduction in microbial load to that observed with sodium hypochlorite. The authors proposed that a garlic-lemon mixture would be an effective alternative to NaOCl [31].

Garlic extract exhibits strong antibacterial activity and biocompatibility. However, when employed in the oral environment, its taste, limited shelf life, and disagreeable odor present significant challenges. In order to enhance the palatability of the medication for the patient, the authors proposed the addition of flavourings [30].

Grape Seed Extract (Vitis Vinifera)

Grape seeds contain phenolic chemicals that possess important medicinal properties. Proanthocyanidins (PA), which are found in grape seeds, enhance the mechanical characteristics of tooth structure by fortifying the collagen fibres in dentinal tubules. Furthermore, they are renowned for their antibacterial, anti- inflammatory, and antioxidant properties [32].

In 2017, Margono et al. conducted a study into the efficacy of grape seed extract derived through maceration at various doses in eliminating the apical third smear layer. The results demonstrated that grape seed extract exhibited a satisfactory, concentration-independent smear layer eradication potential, with a marginally lower efficacy than that of 17% EDTA [33]. In 2018, Soligo et al. demonstrated that 50% grape seed extract was as effective as 6% NaOCl in reducing bacteria in canals infected with E. faecalis [34]. However, further research is necessary to ascertain its capacity to penetrate deeply into dentinal tubules, its efficacy as a bactericidal agent against various species present in the canal system, and the potential for tooth discolouration [32].

Turmeric (Curcuma Longa)

In an in vitro model, curcumin has been demonstrated to be effective against the following bacteria: Actinomyces viscosus, Porphyromonas gingivalis, Lactobacillus casei, Streptococcus mutans, and Prevotella intermedia, as reported by Praveenkumar et al. (2013) [35].

Neelakantan et al. (2013) demonstrated that curcumin was more efficacious than 2% CHX in the elimination of E. faecalis biofilm, and that it was equally effective as 3% NaOCl [9]. In 2015, Neelakantan et al. demonstrated that a biofilm of Enterococcus faecalis may be removed from the walls of root canals using photoactivated curcumin [36]. The main benefits of curcumin include its availability, affordability, long shelf life, and minimal toxicity. Its in vivo efficacy remains unknown, however, as all published investigations assessing its impact on endodontic bacteria are currently conducted in vitro [12].

Cinnamon (Cinnamomum Zeylanicum)

The ethanol extract of cinnamon demonstrated efficacy against both E. faecalis and Candida albicans when tested as an endodontic irrigant on human teeth [30]. A 2015 study by Bardaji et al. found that cinnamon essential oil did not inhibit the growth of E. faecalis. However, it did exhibit a modest level of action against Actinomyces naeslundii, Prevotella nigrescens, Fusobacterium nucleatum, and Streptococcus mutans [37]. In 2018, Ala Mahdi et al. demonstrated that 25% cinnamon extract exhibited comparable antibacterial activity to 5.25% NaOCl, with the exception of Staphylococcus aureus, for which NaOCl demonstrated superior efficacy, creating a larger inhibitory zone [38].

Tea Tree Oil (Melaleuca Alternifolia)

Neelakantan et al. (2011) reported that tea tree oil, derived from Melaleuca alternifolia leaves, has a slight solvent activity and may be beneficial in the dissolution of necrotic pulp tissue [9]. The antibacterial efficacy of tea tree oil was found to be comparable to that of sodium hypochlorite and chlorhexidine in an agar well diffusion method investigation comparing the antibacterial activity of these three substances against E. faecalis [39]. It is of the utmost importance to conduct further research in order to ascertain the toxicity of tea tree oil prior to recommending its clinical use [39].

Guava (Psidium Guajava)

The guava tree (Psidium guajava) is a species of fruit tree native to tropical regions of the Americas. It belongs to the Myrtaceae family. The in vitro effectiveness of guava leaf ethanol extract against E. faecalis and S. mutans has been documented [40]. Furthermore, a 20% ethanol extract from Psidium guajava has been demonstrated to exhibit high antibacterial activity against E. faecalis, comparable to that of 2% chlorhexidine [41]. Although the guava leaf extract demonstrated less efficacy than 2.5% NaOCl, it exhibited notable antibacterial activity against E. faecalis and exhibited minimal to no cytotoxic effects at varied doses [42].

Carvacrol

Carvacrol (2-methyl-5-isopropylphenol) is a monoterpene phenol that has an oregano-like warm, pungent smell and a viscous oil consistency. A number of businesses, including Sigma Aldrich, Biocore, MP Biochemicals, Life Chemicals, and Glentham Life Sciences Ltd., offer it for sale commercially [43].

A 2009 study by Nasrat et al. demonstrated that carvacrol possesses anti-inflammatory properties and can eradicate 99% of bacteria (E. faecalis) in 5 minutes when used as an endodontic irrigant at a concentration of 0.6% [44]. Given that carvacrol is as efficacious as calcium hydroxide in eliminating E.faecalis, it has also been proposed as an intracanal treatment [45]. However, before authorising its application in clinical practice, further scientific research is required.

3/ Intracanal Medication

Casearia Sylvestris Swartz

The Salicaceae family of plants is native to tropical America and Brazil. One of its members, Casearia sylvestris Swartz, is a medicinal herb. It has been demonstrated to possess antibacterial and anti-inflammatory properties [39] In a study published in 2017, Cavenago et al. found that combining MTA with propylene glycol extracts from Casearia sylvestris resulted in increased antibacterial efficacy with no compromise to MTA's biocompatibility [9].

Papain / Morinda Citrifolia

The enzyme papain, which has strong anti-inflammatory and antibacterial qualities, is extracted from the latex that lies between the papaya pulp and bark [47]. In terms of antibacterial activity, the gel of Morinda citrifolia (86.2%) demonstrated superior perfor-

mance to the gels of aloe vera (78.9%), papain (67.3%), and calcium hydroxide (64.3%) in the context of dentinal tubule contamination with E. faecalis. Conversely, the antibacterial action of 2% chlorhexidine gel was most effective against E. faecalis [47].

Tulsi (Ocimum Sanctum or Ocimum Tenuiflorum)

Ocimum sanctum, also known as holy basil, and Ocimum tenuiflorum, are two varieties of the herbaceous plant belonging to the Lamiaceae family. They are widely cultivated in India. In contrast to 2% CHX, Tulsi and Neem extracts have been demonstrated to exhibit a considerable antibacterial impact on primary endodontic infections, as evidenced by an in vivo study conducted by Goldy Rathee et al. in 2020. Consequently, the authors have proposed their utilisation for intracanal medicine and irrigation [48].

Propolis

Propolis has been identified as a more biocompatible and less cytotoxic alternative to calcium hydroxide, with a number of in vitro studies demonstrating its efficacy as an intracanal drug [46]. Indeed, Awawdeh et al. (2009) demonstrated that a 30% propolis solution exhibited superior antibacterial activity against the E. faecalis species when compared to calcium hydroxide at both one and two days [49].

A 2012 study by Carbajal et al. demonstrated that, following 14 days of treatment, propolis was more effective than calcium hydroxide against E. faecalis and demonstrated efficacy against E. faecalis comparable to that of a 2% CHX gel. However, against C. albicans, only CHX (2%) demonstrated statistically significant antifungal activity [68].

Greater Burdock (Arctium lappa)

Due to its therapeutic properties, great burdock (Arctium lappa), a plant in the Asteraceae family, is employed in traditional medicine across the globe. An in vitro investigation conducted by Tonea et al. in 2006 demonstrated that an experimental mixed extract of Arctium lappa root powder and Aloe vera gel exhibited high resistance against a range of pathogens, including E.faecalis and C.albicans [50].

Aloe Vera Gel

Aloe vera gel has been demonstrated to inhibit the growth of numerous oral pathogens, including Streptococcus pyogenes, Enterococcus faecalis, and Candida albicans. The mechanism of action appears to involve the anthraquinones, which are phenolic chemicals, present in the gel [51]. A review of the literature reveals that aloe vera gel is not recommended for use as an intracanal irrigant, and that opinions on its effectiveness against E. faecalis are divided. Conversely, it has been employed as a file lubricant during canal shaping [52].

A study conducted in 2020 utilising the colony-forming unit counting method to assess the efficacy of aloe vera gel as an intracanal medication revealed that it was more effective than calcium hydroxide at eradicating E. faecalis biofilm cultured on extracted teeth. Aloe vera gel has been described in the literature as a naturally occurring antioxidant product with strong antibacterial activity and biocompatibility with periapical tissue. The impact of aloe vera gel on dentin's physical characteristics and fracture resistance, however, remains uncertain [53].

Licorice (Glycyrrhiza Glabra)

Licorice is known to possess antibacterial, anti-inflammatory, antiviral, and anticancer properties [43]. Badr et al. (2010) demonstrated that licorice extract, when administered as an intracanal medicine (either alone or in combination with Ca(OH)2), exhibited a pronounced effect on E. faecalis. Furthermore, it was demonstrated to be less harmful to cells than Ca(OH)2 and biocompatible with fibroblasts [54, 35].

Cumin (Cuminum Cyminum)

The Mediterranean region is the habitat of the herbaceous plant known as cumin (Cuminum cyminum), which belongs to the Apiaceae family. A multitude of studies have demonstrated that cumin possesses antibacterial, analgesic, anti-inflammatory, and antioxidant properties [46]. In a 2016 study, Abbaszadegan et al. examined the effects of 2% CHX gel and Cuminum cyminum essential oil as an intracanal treatment on planktonic and biofilm forms of bacteria isolated from teeth with persistent apical periodontitis. The outcomes demonstrated that the essential oil of C. cyminum was a more effective antibacterial agent than CHX against every studied type of microorganism (aerobic bacteria, anaerobic bacteria, and E. faecalis) [55].

Conversely, the potential interactions between this oil and root canal filling materials or dentinal tubules remain unknown. Consequently, until further research is conducted with a high degree of scientific evidence, it is not possible to provide advice on the use of this substance as an intracanal drug [55].

4/ Endodontic Retreatment

Orange Oil (Citrus Sinensis), Eucalyptus Oil (Eucalyptus Globulus)

Recent studies have demonstrated that limonene-dominated orange oil can dissolve endodontic sealers and soften gutta-percha to a similar extent as xylene, chloroform, and eucalyptol. Furthermore, the efficacy of orange oil in disrupting the integrity of a range of endodontic sealers has been demonstrated, including those based on zinc oxide-eugenol (Endofill and Intrafill), silicon polydimethylsiloxane (RoekoSeal), and calcium hydroxide (Sealer 26) [56, 27, 57].

Furthermore, the efficacy of clove oil, orange oil, and eucalyptus oil to dissolve gutta-percha cones coated in resin was tested by Kulkarni et al. in 2016. The results demonstrated that orange oil exhibited superior efficacy compared to the other tested solvents. [58]. Furthermore, orange oil is inexpensive, biocompatible, readily available, pleasant-smelling, and possesses antimicrobial properties.

5/ Endodontic OBTURATION

Copaïba Oil

In 2020, Reiznautt et al. conducted an investigation with the objective of evaluating the physical-chemical properties, antimicrobial activity, and cytocompatibility of endodontic sealants based on resin that contain essential oils of Butia capitata or Copaïba [59].

The substance employed in this study was RealSeal™, a commercial resin with a methacrylate basis. In the current study, Reiznautt et al. discovered that the evaluated sealants exhibited appropriate physico-chemical properties, antibacterial actions, and excellent cytocompatibility. In contrast to RealSeal™, the natural oil-containing sealants demonstrated reduced fibroblast cell death [59]. Prior to the medication's approval for clinical use, further in vivo toxicity testing is required [60].

Bixa Orellana, Mentha Piperita and Tagetes Minuta

In a further study conducted by dos Santos et al. in 2021, the physical characteristics and antimicrobial activity of experimental resin-based endodontic sealers were evaluated. These sealers included plant extracts at mass concentrations of 0.5% from the species Tagetes minuta (marigold), Mentha piperita (peppermint), and Bixa orellana (annatto). A commercial reference, RealSeal, was employed [61].

The authors found that the physical characteristics of RealSeal remained unaltered by the inclusion of plant extracts. Furthermore,

each extract exhibited antibacterial properties against Escherichia faecalis. Following a 24-hour exposure period, Tagetes minuta and Bixa orellana demonstrated antibacterial activity against Streptococcus mutans. Studies on Mentha piperita have demonstrated that even at low concentrations, it inhibits pathogens such as C. albicans, Staphylococcus aureus, and Escherichia coli.

Dos Santos et al. reached the conclusion that these experimental sealers show promise as novel plant-based sealing materials, based on the results of their study. Nevertheless, further research is required to substantiate these findings [61].

6/ Regenerative Endodontics

It has been recommended to use a low concentration of NaOCl at 1.5% in regeneration procedures. However, controversies persist regarding the ability of low concentrations of NaOCl to completely eradicate infected biofilms. Hence, it is important to search for alternative antimicrobial products of natural origin.

Morinda Citrifolia

A 2018 study by Al Moghazy et al. compared the impact of several irrigation solutions, including Morinda citrifolia, a natural irrigant, on the ability of human dental pulp stem cells to adhere to the dentin walls of root canals. The findings of this study indicate that the combination of Morinda citrifolia and EDTA facilitates the attachment and adherence of pulp stem cells to the root canal walls. This suggests that Morinda citrifolia may be a valuable irrigation solution for regenerative endodontic treatment in the future. [62].

Chrysin

It is postulated that natural flavonoids, such as chysin (5,7-dihydroxyflavone), constitute an active component of honey, passion fruit, Indian trumpet flower, and European propolis [63]. Chrysin's anti-inflammatory, antioxidant, and mineralisation qualities were evaluated in a study utilising dental pulp stem cells (DPSCs). The findings indicate that chrysin may be a promising substitute for dentin-pulp complex regeneration, as it has the potential to both reduce infection and inflammation and encourage the odontoblastic differentiation of dental pulp stem cells [63].

Curcumin

In 2021, Alipour et al. evaluated the scaffolding capacity of polycaprolactone (PCL)-curcumin-laden gelatin in reducing infection and inflammation, as well as inducing mineralisation during the healing of the dentin-pulp complex. The results demonstrated that the scaffolding PCL/Gelatin/Curcumin exhibited antibacterial, antioxidant and anti-inflammatory effects, as evidenced by the inhibition of tumour necrosis factor α (TNF-α) and 2',7'- dichlorofluorescein (DCF) in human dental pulp stem cells (hDPSC). Furthermore, the curcumin-laden material provided an appropriate structure for stem cell fixation and proliferation [64].

7/ Bone Regeneration after Endodontic Surgery

Aloe Vera Acemannan

The β-(1-4) acetylated polymannose found in Aloe vera gel is known as acemannan. Two randomized controlled trials with a 12--month observation period assessed bone repair following treatment with an acemannan sponge after tooth extraction and apical surgery, respectively [65, 66].

Propolis

In 2018, Zohery et al. conducted a comparative study on the effects of Egyptian propolis and nanohydroxyapatite graft on the regeneration of furcation defects in dogs. The results demonstrated that the collagen/propolis group exhibited enhanced osteoblastic

activity and a notable elevation in interradicular bone height when compared to the collagen/nanohydroxyapatite group [67].

Propolis has been demonstrated to possess osteoconductive and osteoinductive properties, rendering it a promising candidate for the treatment of bone abnormalities. Its antioxidant action, capacity to promote cell proliferation, and suppression of bone resorption collectively contribute to its efficacy in this regard [67].

Conclusion

The potential of phytotherapy in endodontics is promising due to its affordability, natural origin, and low toxicity. Nevertheless, further research studies are necessary to define its precise application guidelines.

It is not recommended that phytotherapy be employed as a replacement for current endodontic practices, but rather as a complement to enhance the quality of care. The integration of phytotherapy into clinical practice represents a significant advancement in improving treatment outcomes while meeting the demand for a more holistic and environmentally friendly approach to oral healthcare.

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