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Review Article

Effectiveness of propolis as a pulp preservation material in vital pulp therapies: A systematic review and meta-analysis

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Abstract

Objective: Preserving pulp vitality is essential for clinicians in both primary and permanent dentition to maintain maxillofacial growth, development and function. Propolis, a natural resinous substance collected by honeybees from plant exudates and known for its anti-inflammatory, antimicrobial, and tissue-regenerative properties, has been proposed as a biocompatible pulp preservation material. This meta-analysis sought to examine the efficacy of propolis as a material for vital pulp therapy (VPT), comparing it to the established standards including mineral trioxide aggregate (MTA) in direct pulp cap (DPC) and formocresol in pulpotomy.

Materials and Methods: The literature search was performed on June 7, 2025, across multiple databases including PubMed, Web of Science, Embase, and Scopus. From the 122 studies identified, 14 were included in systematic review and 7 in meta-analysis.

Results: The results indicated no significant difference in the failure rate of teeth undergoing DPC between the MTA and propolis groups at the 3-month follow-up. However, at the 6- and 12-month follow-ups, the propolis group demonstrated higher failure rates compared to the MTA group, with Risk Ratio [RR]s of 2.87 (95% Confidence Interval [CI]: 0.94–8.78), p = 0.66 and 2.59 (95% CI: 0.73–9.21), p = 0.79, respectively. Despite these trends, the differences were not statistically significant. Additionally, no significant difference was found between formocresol and propolis groups regarding the clinical failure rate of pulpotomized teeth (RR = 0.54; 95% Confidence Interval [CI]: 0.05–6.20), p = 0.62.

Conclusion: These meta-analyses suggest no statistically significant difference in failure rates between propolis and MTA at the 3, 6- and 12-month follow-ups. However, the 6- and 12-month data show a non-significant trend favoring MTA. These findings should be interpreted cautiously due to the limited sample size and number of studies.

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Introduction

Vital pulp therapy (VPT) which includes direct pulp capping (DPC) and pulpotomy, is a series of treatments for decayed or damaged teeth. These procedures aim to remove the affected part of the tooth to save the remaining pulp tissue, thus maintaining the tooth's health and function (Ahmad et al. 2022). VPT mainly aims to induce a dentine bridge formation in order to close the pulp exposure area (Nasri et al. 2022). Preserving the vital part of the pulp is important in both primary and permanent dentition. Primary dentition is essential for proper maxillofacial growth and development, as it maintains the space required for the healthy eruption of permanent teeth (da Silva and Gleiser 2008). Premature loss of primary teeth can disrupt the development of permanent teeth, leading to ectopic eruption, altered angulation, impaction, crowding, and dead spaces. These issues can result in aesthetic and functional problems such as food trapping, halitosis, gum infections, speech distortion, and gastrointestinal complications (Izidoro et al. 2022; Nadelman et al. 2020). These consequences also arise from the loss of permanent teeth. Therefore, it is crucial to avoid injuring pulp tissue during dental procedures or, if injury occurs, to strive for its preservation to maintain dental health.

Despite advancements, current materials for VPT face significant limitations. Mineral Trioxide Aggregate (MTA), while considered the gold standard, has drawbacks such as difficult handling, prolonged setting time (up to 4 hr), tooth discoloration, and high cost (Desai et al. 2025). Similarly, formocresol, historically used in pulpotomy, raises safety concerns due to its mutagenicity and carcinogenicity, alongside poor promotion of dentin bridge formation (RojaRamya et al. 2022). These limitations highlight an urgent need for biocompatible, cost-effective alternatives that address both clinical efficacy and safety.

Propolis, a natural resinous product collected by bees from plant exudates, has emerged as a promising option for vital pulp therapy. It is composed primarily of resins (50%–70%), aromatic oils and waxes (30%–50%), and pollens (5%–10%), along with various organic compounds such as amino acids, minerals, sugars, and vitamins (B, C, and E). Its composition may vary according to factors such as geographical origin, climate, and harvesting period (Sforcin et al. 2000). The biological activity of propolis is largely attributed to its rich content of flavonoids, phenolic acids, and other aromatic compounds, which provide antimicrobial (Ferreira et al. 2007), antioxidant, anti-inflammatory (Tan-No et al. 2006), and bone-regenerative properties (Al-Haj Ali 2016; Ozório et al. 2012). These mechanisms include the reduction of inflammatory responses through inhibition of prostaglandin production in the arachidonic acid pathway, which is critical in pulp inflammation. Owing to this wide spectrum of effects, propolis has found diverse applications in dentistry, including use as a root canal irrigant (Matochek et al. 2020), intracanal medication and disinfectant (Almadi et al. 2021), and as a pulp preservation material in direct pulp capping (Ahmad et al. 2022) and pulpotomy (Goinka et al. 2023). Numerous studies have demonstrated comparable outcomes between propolis and gold-standard materials in VPT for both primary and permanent teeth (Ahmad et al. 2022; Goinka et al. 2023; Nasri et al. 2022; RojaRamya et al. 2022).

An ideal material for vital pulp therapy must possess several key characteristics. These include preserving pulp vitality, bonding effectively to both tooth structure and restorative material, sealing the exposed area, and maintaining sterility. Additionally, the material should exhibit bactericidal or bacteriostatic properties, along with radiopacity (Patel et al. 2020). The search for an optimal material to cover pulpal exposures has evolved from eugenol and zinc oxide to calcium hydroxide and

subsequently, to MTA. MTA has revolutionized DPC due to its superior sealing ability, overcoming the shortcomings of its predecessors such as poor sealing and high solubility, establishing itself as the gold standard material in contemporary dentistry (Ahmad et al. 2022). Nonetheless, ongoing challenges with MTA have prompted researchers to actively develop and evaluate new synthetic and natural alternatives, among which propolis has gained particular attention. Consequently, researchers are actively developing and comparing new synthetic and natural products as potential alternatives to MTA.

Pulpotomy, a common procedure in VPT for primary teeth, often involves the use of formocresol to disinfect the pulp chamber and preserve the superficial layer of the radicular pulp tissue. Pulpotomy has traditionally involved the use of formocresol; however, concerns about its safety and limited regenerative capacity have encouraged the exploration of more biocompatible substitutes (Goinka et al. 2023) .

With the recent emphasis in the scientific literature on natural products in dentistry, this systematic review and meta-analysis sought to examine the efficacy of propolis as a material for VPT, comparing it to established gold standards and exploring a non-inferiority meta-synthesis. The research question addressed was:

"Does the utilization of propolis in DPCs and pulpotomies yield outcomes comparable to those achieved with current gold standard materials?"

Materials and Methods

The current meta-analysis adhered to the guidelines outlined in the Cochrane Handbook for Intervention Reviews (Higgins et al. 2023) and followed the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines 2020. The study protocol was registered in the international prospective register of systematic reviews (PROSPERO) under the registration code CRD42024530769.

Eligibility criteria

The eligibility criteria, based on the PICO framework, are outlined as follows:

Population: Individuals who have undergone pulpotomy or DPC.

Intervention: using propolis as VPT material.

Comparison: MTA or calcium hydroxide in DPC, formocresol in pulpotomy.

Outcome: primary outcomes include pain and success rate, while secondary outcomes encompass histological features such as dentin bridge formation and tissue inflammation.

Clinical controlled trials were included, while reviews, retrospective studies, cohorts, and animal studies were excluded.

Databases and search

The literature search was performed on June 7, 2025, across multiple databases, including PubMed, Web of Science, Embase, and Scopus. Keywords were derived from MeSH terms of PubMed and Emtree of the Embase database, supplemented with additional free keywords combined with Boolean operators (AND/OR/NOT) and truncation. Database-specific adaptations were made to optimize retrieval (e.g. PubMed filters: Humans, Clinical Trial, English; Scopus: TITLE-ABS-KEY). Google Scholar and ProQuest Dissertation & Theses online databases were also utilized to identify relevant articles. Additionally, reference lists of the final included articles were manually searched. The search strategy employed for each online database is provided in Supplementary Material 1.

Study selection and data extraction

The screening phase involved two authors (MH and DF) who were independently and in duplicate. Initially,

studies were screened based on title/abstract, with those remaining undergoing full-text evaluation. Discrepancies were resolved through group discussion. A data extraction Table was devised during the pilot phase by reviewing relevant literature and summarizing the studies to be included. This Table encompassed the first author's name and publication date, study design, tooth type, study arms, sample size, assessed outcomes, follow-up duration, and main findings for each included study. Subsequently, the data extraction was performed independently and in duplicate by two authors (MH and DF), with discrepancies resolved in the same manner as in the screening phase. For studies with multiple intervention arms (e.g. comparing propolis to both MTA and calcium hydroxide), data extraction followed the Cochrane Handbook recommendations (Higgins et al. 2023):

If a study included multiple experimental groups (e.g. different propolis formulations), only the arm matching our predefined PICO criteria (propolis as a VPT material) was included.

If a study included multiple control groups (e.g. MTA and calcium hydroxide), separate pairwise comparisons (propolis vs. MTA; propolis vs. calcium hydroxide) were extracted to avoid double-counting the control group.

For multi-arm trials comparing propolis to both a VPT material (e.g. MTA) and a non-VPT intervention, only the VPT-relevant comparison was retained.

Risk of bias assessment

The risk of bias assessment was carried out independently and induplicate (SH and DF), utilizing the Joanna Briggs Institute (JBI) critical appraisal checklist (Tufanaru et al. 2020). Discrepancies were resolved through group discussion. This checklist encompasses essential aspects of Randomized Controlled Trial (RCT) studies, addressing potential sources of bias such as randomized sample selection, allocation concealment, levels of blinding, and appropriateness of statistical analyses. The summary graph of the risk of bias assessments was generated using the Robvis visualization application (McGuinness and Higgins 2021).

Meta-analysis

The meta-analysis and generation of forest plots were performed using the Meta-Mar online application v3.5.1, developed at Shahid Beheshti University. For the dichotomous variable of "failure rate", defined as treatment success or failure within a specified follow-up period, the risk ratio (RR) and a 95% confidence interval were employed. Statistical heterogeneity was assessed using the chi-square test (Cochrane Q), with significance set at $p<0.05$ and the I^2 statistic. An I^2 value exceeding 50% indicated high heterogeneity. In cases of substantial methodological heterogeneity among included studies, a random-effects model was applied (Higgins et al. 2023).

Results

Out of the 122 studies identified during the search phase, 44 were eliminated as duplicates, and an additional 40 were excluded during title/abstract screening due to irrelevant topics. The remaining 38 studies underwent full-text evaluation, with 24 deemed irrelevant and set aside. The search and screening process is illustrated in a flow chart following the PRISMA guidelines (Figure 1).

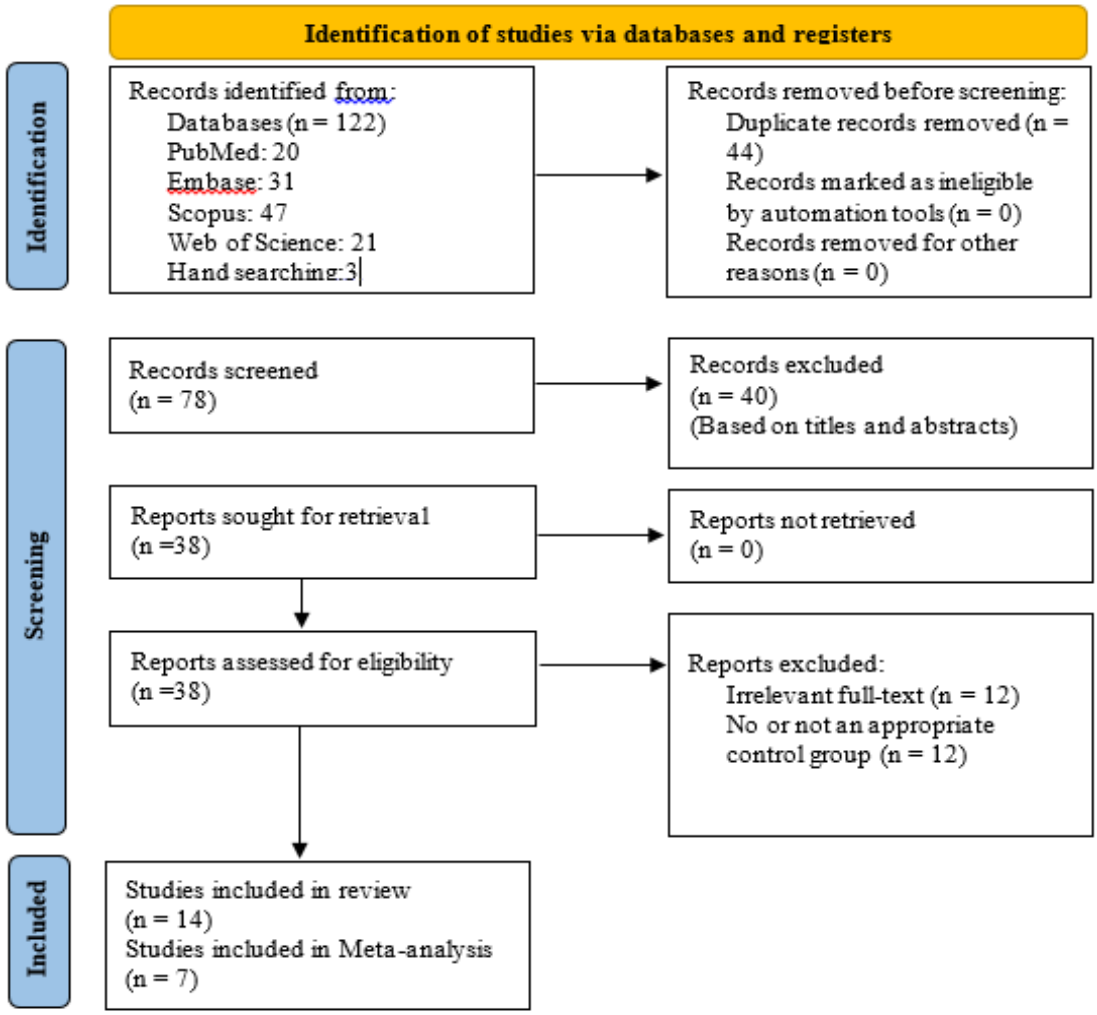

Figure 1. PRISMA flowchart

Characteristics of included studies

This meta-analysis included a total of 767 teeth from 14 included articles. Among these, six studies focused on DPC (Ahmad et al. 2022; Elasser et al. 2025; Mohanty et al. 2020; Nasri et al. 2022; Parolia et al. 2010; Rasheed et al. 2020), while eight investigated pulpotomies (Aghazadeh et al. 2018; Alolofi et al. 2016; Goinka et al. 2023; Hugar et al. 2017; Kusum et al. 2015; Madan et al. 2020; Reddy et al. 2019; RojaRamya et al. 2022). Follow-up periods ranged from 15 days (Ahmad et al. 2022) to 2 years (RojaRamya et al. 2022). Various outcomes were evaluated, including survival rate, clinical signs (pain, hypersensitivity, and discomfort), radiographic changes, and histological features (dentine bridge formation, and tissue inflammation). MTA and formocresol were utilized for control groups in DPC and pulpotomy studies, respectively. The meta-analysis included subsets of the total systematic review sample (767 teeth). For Propolis vs. MTA in direct pulp capping, 83 teeth (3-month), 161 teeth (6-month), and 95 teeth (12-month) were analyzed. For Propolis vs. formocresol in pulpotomy, 158 teeth (6-month) were included.

Risk of bias assessment

Supplementary Material 2 contains the detailed results of the risk of bias assessment phase, along with the questions from the JBI checklist. Figure 2 presents the overall outcome of the risk of bias assessment. A comprehensive risk of bias assessment was conducted across 13 methodological domains for the studies

included in the meta-analysis. The majority of domains demonstrated a low risk of bias, particularly in areas related to statistical analysis, outcome measurement, and overall trial design, as introduced by the predominance of low-risk ratings. However, concealment and blinding of participants and treatment providers, exhibited higher proportions of high and unclear risk reflecting potential methodological limitations in theses aspects. Notably, the domains addressing randomization and follow-up completeness showed some uncertainty, with a moderate presence of unclear risk rating. Minimal instances of missing information were observed, suggesting that most studies provide sufficient methodological details for evaluation.

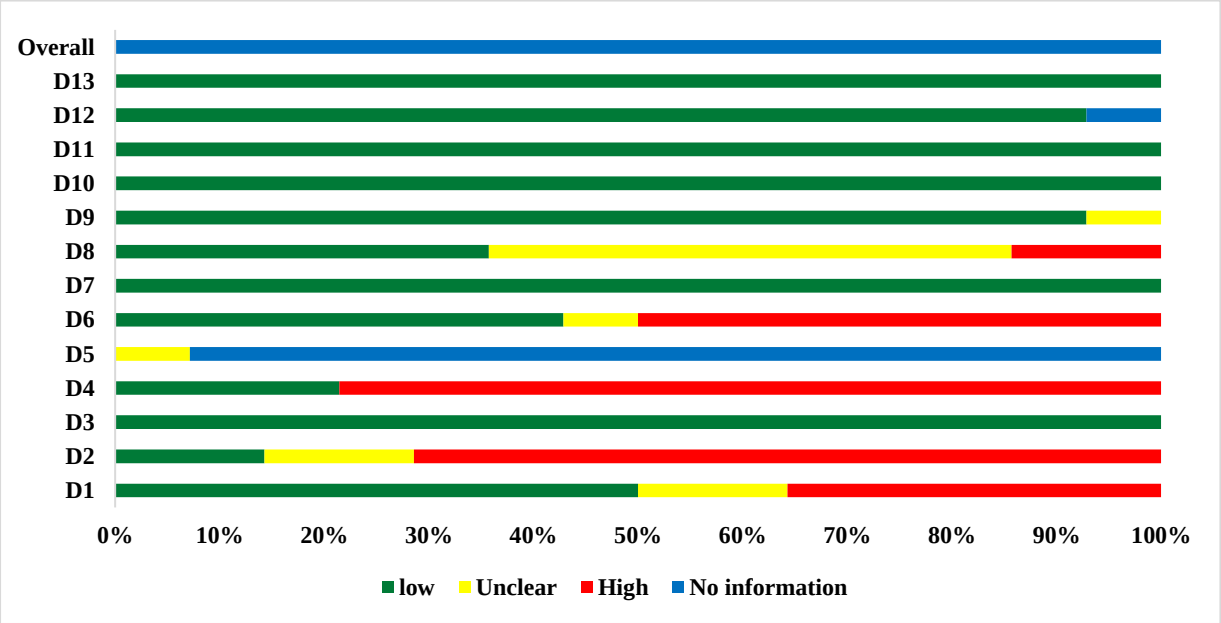

Figure 2. Risk of bias assessment summary

Meta-analysis

Propolis vs. MTA as pulp capping material

Figure 3 illustrates the comparison between propolis and MTA as pulp capping materials at 3, 6, and 12-month intervals. In the initial meta-analysis (3-month follow-up), two studies (Kusum et al. 2015; Madan et al. 2020) were included. The RR of 0.99 suggests that the risk of clinical failure is nearly the same between propolis and MTA (95% Confidence Interval [CI]: 0.11-9.17). The meta-analysis incorporated data from four studies evaluating the clinical failure rates of propolis compared to MTA at a 6-month follow-up period. The pooled Risk Ratio (RR) was 2.87 (95% CI: 0.94-8.78) suggests a trend toward a higher risk of clinical failure in the propolis group compared to the MTA group at 6 months, however this difference was not statistically significant.

The meta-analysis included two studies that assessed clinically observed failure rates of propolis compared to MTA at 12 months. The pooled risk ratio (RR) was 2.59 (95% CI: 0.73 to 9.21), indicating that the risk of clinical failure in the propolis group was approximately 2.6 times that of the MTA group. Although the I^2 and chi-square tests indicated no statistically significant heterogeneity, these results should be interpreted with caution due to the limited number of included studies and small sample sizes. Additionally, the wide confidence intervals reflect a high degree of uncertainty in the effect estimates. Additionally, publication bias was not feasible to assess for the same reason.

Propolis vs. formocresol as pulpotomy material

Figure 4 displays the outcome of the comparison between propolis and formocresol as pulpotomy agents at the 6-month follow-up. This meta-analysis included three studies (Alolofi et al. 2016; Hugar et al. 2017; Reddy et al. 2019). No significant difference was observed among these groups regarding failure rate. However, the chi-square test significance and the I_2 statistic (>50) indicated high statistical heterogeneity among the included studies. As a result, assessing publication bias was not feasible due to the limited number of included studies and small sample sizes.

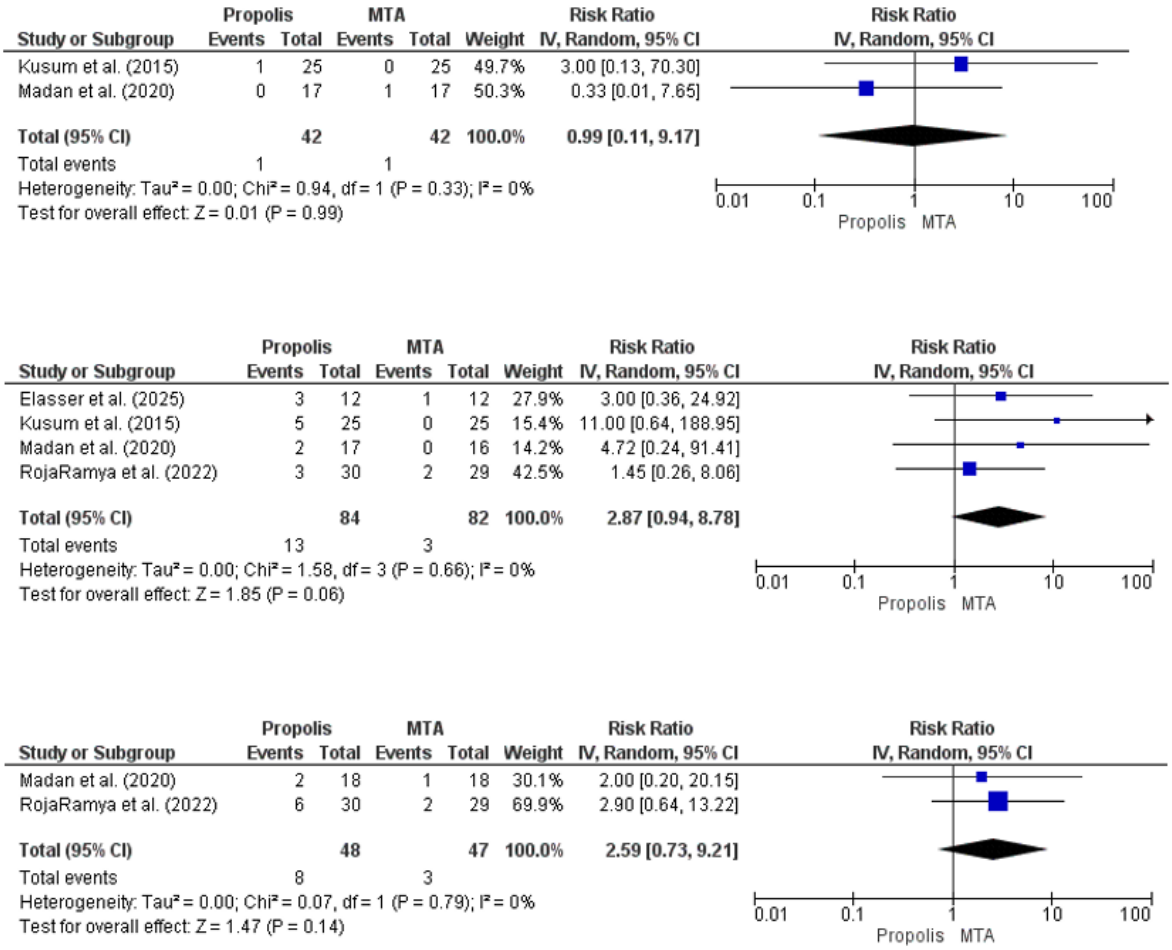

Figure 3. Propolis vs. MTA used as pulp capping material respectively at 3-, 6-, and 12-month follow-up.

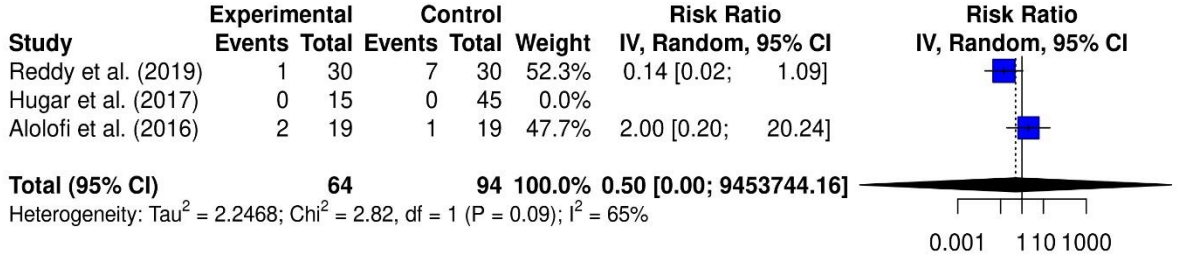

Figure 4. Propolis vs. formocresol used as pulpotomy material at 6-month follow-up.

Discussion

An ideal material for VPT should exhibit antibacterial properties, be well-tolerated by pulp tissues, demonstrate no toxicity, and promote dentine bridge formation (Ahmad et al. 2022). While MTA currently serves as the gold standard material for VPT, it comes with certain limitations, prompting the search for improved alternatives, preferably natural products that are cost-effective. In light of the recent literature focus on exploring new materials suitable for VPTs, this meta-analysis aimed to compare propolis as a VPT material with MTA in DPCs and formocresol in pulpotomies.

Propolis has recently emerged as an effective agent in various domains of dentistry such as canal irrigation solutions and intracanal medication, and as a storage medium in dental trauma cases (Ahangari et al. 2018). Studies have highlighted its potential to stimulate stem cells (El-Tayeb et al. 2019) and promote bone tissue regeneration by inhibiting osteoclastogenesis (Yuanita et al. 2018). Moreover, propolis contains anti-inflammatory compounds like acacetin, apigenin, and caffeic acid phenethyl ester (Toreti et al. 2013). Its flavonoid compounds possess antibacterial properties that can effectively inhibit bacterial growth (Ferreira et al. 2007).

This meta-analysis suggests that while MTA may offer superior short-term outcomes in DPC, the long-term performance of propolis appears clinically comparable. Similarly, propolis demonstrated non-inferior outcomes to formocresol in pulpotomy cases, despite inherent methodological variability. These findings highlight the potential of propolis as an alternative material, especially when the limitations of conventional agents must be addressed. Although statistical heterogeneity was limited in some comparisons, clinical and methodological variability remained high and must be considered when interpreting the pooled estimates.

Indeed, considerable heterogeneity was observed among the reviewed studies, which may have influenced the overall estimates. This heterogeneity stems from several key sources:

(1) Variability in propolis composition, which varies by geographic origin, harvest season, and plant source and was not consistently reported across the reviewed studies. This lack of standardization may affect the bioactivity and therapeutic potential of propolis across trials (Sforcin et al. 2000).

(2) Differences in propolis preparation and application techniques including different solvents (e.g. ethanol concentration), delivery vehicles, and setting characteristics. Procedural variations—including pre-intervention chlorhexidine use (Nasri et al. 2022; Parolia et al. 2010; Rasheed et al. 2020), pulp chamber disinfection protocols (5.2% NaOCl vs. saline irrigation) (Ahmad et al. 2022; Goinka et al. 2023; Madan et al. 2020; RojaRamya et al. 2022), isolation techniques (rubber dam application) (Goinka et al. 2023; Madan et al. 2020; Nasri et al. 2022; RojaRamya et al. 2022), and temporal placement strategies (permanent vs. temporary)—likely induced differential pulp responses, confounding outcome harmonization.

(3) Differences in follow-up duration, ranging from 15 days to 24 months, lead to temporal variability in outcome measurements and dentin bridge observation. Shorter follow-ups may underrepresent the regenerative potential of propolis that becomes apparent over longer healing periods.

Taken together, these sources of heterogeneity limit direct comparisons and highlight the need for standardized methods in future trials investigating propolis for VPT.

The predominant method utilized for applying propolis as a material for pulpotomy or DPC in the included studies involved mixing its powder with 70% ethyl alcohol to achieve a thick paste consistency.

This paste was then either permanently (Ahmad et al. 2022; Goinka et al. 2023; Mohanty et al. 2020; Nasri et al. 2022; Parolia et al. 2010; Rasheed et al. 2020; Reddy et al. 2019) or temporarily (Hugar et al. 2017; Madan et al. 2020; RojaRamya et al. 2022) placed into the pulp chamber. According to the majority of the included studies (Ahmad et al. 2022; Goinka et al. 2023; Parolia et al. 2010; Rasheed et al. 2020; Reddy et al. 2019; RojaRamya et al. 2022), propolis demonstrated good tolerance by the exposed pulp tissue, with the observed severity of the inflammatory response being comparable to or even lower than that of the MTA and formocresol groups. Only one study reported relatively weaker outcomes for propolis in terms of the thickness and continuity of dentinal bridge formation (Mohanty et al. 2020).

Additionally, unlike formocresol, propolis has demonstrated the ability to induce dentin bridge formation in areas in contact with exposed pulp tissue. This effect was notably successful in both pulpotomy and DPC, as indicated by the included studies (Table 1). Moreover, instances of pain and discomfort were infrequent in cases treated with propolis, with the rate being comparable to that of the control group.

Although blinding the researchers performing the intervention might have been challenging due to the distinct preparation processes and characteristics of the materials used in each group, blinding of participants and outcome assessors was feasible yet overlooked in most of the included studies. Moreover, the randomization process was inadequately conducted and reported in detail, which is a critical aspect affecting the validity of the study results. Allocation concealment, another crucial element of bias, was not adequately addressed in most studies. The limited number of included studies and their small sample sizes were significant limitations, necessitating the need for future studies with robust designs to provide more reliable evidence regarding the effectiveness of propolis in VPTs.

Based on our findings, propolis may be particularly suitable in clinical settings where conventional materials such as MTA or formocresol are contraindicated or impractical. For example, in resource-limited settings, propolis—a naturally derived, low-cost material—offers an accessible alternative with acceptable short- to medium-term results. Furthermore, for younger patients or those who have concerns about synthetic agents, propolis offers a biocompatible and aesthetically pleasing option because, unlike MTA, it does not discolor teeth. Its antimicrobial and anti-inflammatory properties may also be useful in cases where infection control and tissue healing are both priorities. However, clinicians should exercise caution due to the variability in preparation and the limited long-term evidence currently available. Until more standardized formulations and protocols are developed, propolis may be best positioned as an adjunctive or temporary option, particularly in selected cases where natural, low-toxicity interventions are prioritized.

The evidence from these meta-analyses suggests no statistically significant difference in clinical failure rates between propolis and MTA at either 3, 6 or 12 months. However, the 6- and 12-month data show a non-significant trend favoring MTA, highlighting the need for further well-designed studies with larger sample sizes and longer follow-up to clarify the comparative efficacy of these treatments. These findings should be interpreted cautiously due to the limited sample size and number of studies. It can be concluded that, propolis demonstrates potential as a material for VPTs. Given its favorable biological properties and cost-effectiveness, it may serve as a practical alternative in settings where MTA is not accessible or contraindicated. Nonetheless, additional research with rigorous methodology is warranted to validate its long-term clinical performance and support broader clinical adoption.

Table 1. Characteristics of the included studies.

Author (Year)	Study design	Tooth type/ Intervention	Study groups	Group size	Assessed outcome	Follow-up	Study results
Goinka et al. (2023)	RCT	Primary/Pulpotomy	Propolis, Formocresol, PDGF	30	Histological features including odontoblastic integrity, pulp inflammation, pulp calcification, dentin bridge formation, and presence of pulp stone.	3, 6 months	Same inflammatory response, soft-tissue organization, dentin bridge formation, and odontoblastic layer integrity in propolis and PDGF, whereas formocresol group did not develop dentin bridge at both time periods.
Ahmad et al. (2022)	Clinical trial	Permanent/Direct pulp cap	Propolis, Biodentine	10	Histological features: formation of dentine bridges, and odontoblastic layers, presence of inflammation	15, 45 days	No dentin bridge formation in 15 days, but newly formed in 45 days thinner than biodentine specimens. Normal pulp tissue as biodentine specimens. Continuous intact odontoblastic layer in both groups. Specimens capped with propolis showed less inflammation.
RojaRamya et al. (2022)	RCT	Primary/Pulpotomy	Propolis, MTA	30	Success rate depending on the clinical and radiographic outcomes	6, 12, 24 months	There was no significant difference in terms of success rate.
Nasri et al. (2022)	RCT	Permanent/Direct pulp cap	Propolis, MTA, Biodentine	12	Histological features: formation of dentine bridge and its continuity, presence of inflammation Clinical features: hypersensitivity and pain	2 months	No significant differences in terms of success rate, clinical and radiographic symptoms were seen among the groups. The presence and severity of pulpal inflammation and dentinal bridge formation were similar in all the experimental groups.
Rasheed et al. (2021)	Clinical trial	Primary/Direct pulp cap	Propolis, MTA and CEM	19	Histological features: "Inflammatory cell response grading"	15 days	There was no significant difference between groups in terms of inflammation severity and pulpal responses.
Madan et al. (2020)	Clinical trial	Primary/Pulpotomy	Propolis, MTA	20	Clinical features: Success rate Pain on percussion Radiographic features	3, 6, 12 months	There was no significant difference in overall success rate, and other evaluated features among study groups at each follow-up periods.
Mohanty and Ramesh (2020)	RCT	Permanent/Direct pulp cap	Propolis, MTA, Biodentine	34	Sensibility alteration Histological features: Dentin bridge formation (continuity, morphology, and thickness)	3 months	Propolis was well-tolerated by the pulpal tissues and successfully induced dentin bridges in all the teeth of its group. Also, none of the treated teeth of this group showed pain and lack of dentine bridge. However, biodentine and MTA significantly did better in terms of thickness and continuity of dentinal bridge.
Reddy et al. (2019)	Clinical trial	Primary/Pulpotomy	Propolis, Formocresol, PDGF	30	Success rate Histological features: formation of dentine bridge and its continuity, presence of inflammation	3, 6 months	Clinical success rate of propolis group was significantly better than formocresol group. Propolis group was significantly superior than formocresol group in terms of dentine bridge formation and its integrity. There was no difference among groups in terms of pulp inflammation severity.
Aghazadeh et al. (2018)	RCT	Primary/Pulpotomy	Propolis, MTA	25	Clinical and radiographic scoring	3, 6, 12 months	MTA was significantly superior in terms of clinical and radiographic scoring.
Hugar et al. (2017)	RCT	Primary/Pulpotomy	Propolis, Formocresol, Turmeric gel, Calcium Hydroxide	15	Clinical features: Success rate Pain and swelling Radiographic features	1, 3, 6 months	No difference was observed among groups in terms of success rate.
Alolofi et al. (2016)	RCT	Primary/Pulpotomy	Propolis, Formocresol, Thymus vulgaris	20	Clinical features: Success rate Pain, swelling and tenderness Radiographic features	1, 6, 12 months	No difference was observed among groups in terms of success rate.
Kusum et al. (2015)	RCT	Primary/Pulpotomy	Propolis, MTA, Biodentine	25	Clinical features: Success rate Radiographic features	3, 6, 9 months	The success rate was significantly lower in propolis group compared to MTA and biodentine groups.
Parolia et al. (2010)	Clinical trial	Permanent/Direct pulp cap	Propolis, MTA and Calcium hydroxide	6	Histological features: Formation of dentine bridge and its continuity, presence of inflammation	15, 45 days	Propolis showed no statistically significant difference in pulp response when compared to Dycal and MTA.
Elasser et al. (2025)	RCT, double-blind, 3-arm trial	Recently erupted permanent molars / Direct pulp capping	Nanopropolis, Nanocurcumin, MTA	12 per group	Pain (VAS), swelling, percussion sensitivity, radiographic changes	1 week, 3 months, 6 months	At 6 months, success in: Nanopropolis (9/12), MTA (11/12); no significant difference ($p > 0.05$)

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Conflicts of interest

The authors declare no competing interests.

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