RECOMMENDATIONS: *CLINICAL PRACTICE GUIDELINE*

Guideline for Use of Vital Pulp Therapy in Permanent Teeth

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Abstract: ***Purpose:*** *To develop permanent tooth vital pulp therapy (VPT) recommendations.* ***Methods:*** *GRADE framework recommendations developed from systematic review data of permanent tooth VPT through June 30, 2024.* ***Results:*** *Teeth with deep caries (extending to inner third or quarter of dentin with intact dentin barrier) diagnosed with normal pulp or reversible pulpitis (NP/RP) can be treated either with indirect pulp treatment (IPT), direct pup cap (DPC), partial pulpotomy (PP), or full pulpotomy (FP) (conditional recommendation, low certainty). Selective caries removal for IPT is strongly recommended (high certainty) for deep caries in NP/RP diagnosed teeth. In case of pulp exposure either DPC, PP, or FP using calcium silicate cement (CS) may be performed regardless of root maturation (conditional recommendation, low certainty). Using sodium hypochlorite (NaOCl) irrigation is strongly recommended for DPC hemostasis (high certainty) over saline and conditionally recommended (very low certainty) for pulpotomy. For permanent teeth with extremely deep caries (no discernible radiographic barrier) or deep carious teeth exhibiting spontaneous, nocturnal, or lingering pain but normal periapical appearance, complete (nonselective) caries removal to expose the pulp for assessment is strongly recommended (moderate certainty). If pulpotomy is indicated in these teeth, FP using CS is recommended over PP (conditional; low certainty). Also, PP and FP success will likely be higher if hemostasis occurs within six minutes (conditional; low certainty). Using magnification likely enhances pulp visualization, facilitating more accurate assessment of its status. Teeth with NP/RP having traumatic exposures, PP/FP is conditionally recommended over DPC. Using nonstaining CS is strongly recommended (high certainty) for VPT on teeth in esthetic areas.* ***Conclusions:*** *Selective caries removal is recommended for teeth having deep caries with NP/RP. CS utilization is recommended for DPC, PP, and FP using NaOCl for hemostasis. Complete caries removal and assessment of pulp status is recommended for teeth exhibiting spontaneous, nocturnal, or lingering pain; if pulp is diagnosed as vital and bleeding is controlled, FP is recommended.* *(Pediatr Dent 2025;47(5):299-311) Received May 14, 2025 / Last Revision July 20, 2025 / Accepted July 22, 2025*

KEYWORDS: INDIRECT PULP THERAPY; DIRECT PULP CAPPING; PARTIAL PULPOTOMY; FULL PULPOTOMY; VITAL PULP THERAPY

Plain language summary

Introduction and purpose of the guideline. This is the first clinical practice guideline devoted solely to vital pulp treatment in permanent teeth created by the American Academy of Pediatric Dentistry (**AAPD**).

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The purpose of the new guideline is to present clinical vital pulp therapy (**VPT**) recommendations for permanent teeth affected by tooth decay or trauma based on a systematic review (**SR**) and statistical analysis of evidence-based studies.

Methods used to create the guideline. The authors conducted an SR of dental literature concerning vital permanent tooth pulp treatments, including 388 articles published through June 30, 2024. These studies were comprised of randomized and nonrandomized controlled trials, plus studies done in laboratories, which are termed in vitro studies. The authors defined treatment success as the patient having no pain or clinical signs or symptoms of infection and radiographs showing no signs of pathology. The SR's data and statistical evaluations provided information from which the clinical recommendations were formulated, including the recommendation's strength and level of certainty. A decision tree figure was developed to identify the recommended pulp therapies. Outside stakeholders and AAPD councils/committees vetted this guideline.

Guideline recommendations. Indirect pulp treatment (**IPT**), direct pulp cap (**DPC**), partial pulpotomy (**PP**), and full pulpotomy (**FP**) show similar success after 24 months. Therefore, all can be used for the treatment of a permanent tooth diagnosed as having normal pulp or reversible pulpitis (**NP/RP**) due to decay. This recommendation is conditional, with a low certainty since it is based on indirect comparisons of 24-month data. It applies to mature teeth in adults or immature teeth in children and adolescents. The guideline strongly recommends that, with a high certainty from 36-month data, when performing a DPC procedure, diluted bleach for irrigation plus a pulp

GLOSSARY of TERMS and ABBREVIATIONS

AAPD American Academy of Pediatric Dentistry.

Biodentine™ brand name of a tricalcium silicate cement, manufactured by Septodont, which is used in vital pulp therapy.

Calcium hydroxide [$Ca(OH)_2$] antibacterial material recommended as a liner material for indirect pulp treatment procedures but not as a direct pulp capping agent in permanent teeth.

Calcium silicate cements (CS) dental cements made from a composition of calcium and silicate.

Deep caries is defined as lesions extending to the inner third or quarter of the dentin but showing a distinct radiographic zone of dentin over the pulp.[3]

Direct pulp cap (DPC) performed on clinically visible pulp exposures from trauma or caries and involves placing a biocompatible material over the exposed pulp, followed by a final restoration to minimize microleakage.

Electric pulp testing (EPT) electronic sensibility test to aid in assessing the health of a tooth's pulp.

Extremely deep caries defined as penetrating the full thickness of the dentin with no discernible radiographic dentin barrier, indicating that pulp exposure is unavoidable.[3]

Firm dentin similar to leathery dentin in appearance but resists hand excavation and requires some pressure from the instrument to be lifted.

Full pulpotomy (FP) a procedure involving the removal of the entire coronal pulp of the tooth and placing a biocompatible material over the remaining root canal pulp tissue to preserve its vitality, followed by placement of a final restoration to minimize microleakage.

Grading of Recommendations Assessment, Development, and Evaluation (GRADE) assessment that rates overall strength and certainty of recommendations related to each outcome studied in forest plots using seven domains.

Hard dentin, representing healthy, sound dentin, exhibits significant resistance to excavation and requires a sharp cutting edge or bur for removal.

Irreversible pulpitis (IP), as referenced in this guideline and determined by the authors of this manuscript, is a clinical diagnosis that categorizes teeth included in various studies that present with signs and symptoms compatible with symptomatic irreversible pulpitis, as defined below.

Indirect pulp treatment (IPT) utilizes selective caries removal to preserve a deep layer of cariously affected dentin, which prevents pulp exposure, followed by application of a biocompatible material and placing a final restoration to minimize microleakage.

Laser Doppler flowmetry uses infrared light to measure the pulp's blood flow to aid in determining if a tooth's pulp is vital.

Leathery dentin does not deform when an instrument is pressed against it, can be easily lifted with minimal force, and exhibits a slight "tackiness" upon contact.

Mineral trioxide aggregate (MTA) type of calcium silicate cement, as defined above, that is used in vital pulp therapy.

Sodium hypochlorite (NaOCl) dental disinfectant, commonly termed chlorine bleach, formed by the reaction of chlorine gas with sodium hydroxide.

Nonselective caries removal (complete) defined as removing all carious tissue, including all demineralized dentin, to reach hard dentin, leaving no soft or leathery dentin.

Number needed to treat (NNT) estimate of the number of teeth or people that need to receive the recommended intervention to see a beneficial outcome.

Normal pulp (NP) clinical diagnosis in which the tooth's pulp is symptom-free and responds normally to pulp testing.

Patient/Population, Intervention, Comparison, Outcome, and Study design (PICOS) is used to structure a clinical research question or topic.

Pulse oximetry relies on the pulp's oxygen saturation levels for determining if a tooth's pulp is vital.

Partial pulpotomy (PP) procedure involving the removal of a small portion of the vital coronal pulp and placing a biocompatible material over the remaining pulp to preserve its vitality, followed by placement of a final restoration to minimize microleakage.

Preoperative periapical involvement (PPI), as referenced in this guideline, is a radiographic lesion at or near the apex of a tooth's root resulting from pulpal inflammation or infection due to dental caries.

Risk of bias (ROB) assessment of the quality of a study's design that is conducted to determine if bias has compromised the credibility of the link between exposure and outcome.

capping material termed calcium silicate cement (**CS**) should be used.

If the decay reaches the inner third or quarter of the tooth's dentin (the layer of the tooth under the enamel) and there is a dentin barrier between the tooth's nerve and the decay, it is defined as deep decay. Teeth with deep decay and no signs of infection can be treated using selective decay removal, a process in which the deepest decay is left in place to avoid nerve exposure. This is strongly recommended with a high certainty of evidence from 60-month data. If a tooth presents with spontaneous, lingering, or nighttime pain and x-rays show no other signs of infection, it is strongly recommended, with moderate certainty based on 24- to 60-month data, to remove all the decay to expose the nerve and evaluate its status to determine if a pulpotomy procedure using CS should be performed. It is conditionally recommended, with low 12- to 24-month certainty, that when performing a FP, pulpal bleeding should be controlled within six minutes for best results. If any VPT involves a permanent tooth that shows in a person's smile, it is strongly recommended with high certainty, to use CS that are nonstaining to avoid dark staining of the tooth postoperatively. For treatment of traumatic pulp exposures, a PP or FP is recommended over DPC due to its significantly higher success. This was a conditional recommendation with a low certainty based on 18- to 24-month evidence.

Guideline

Introduction and purpose. The pulp therapy workgroup (**WG**) of the AAPD developed this guideline. The document was based on a SR and meta-analyses current through June 2024.[1] The purpose of the recommendations contained in this guideline was to assist clinicians and patients in treatment decisions regarding VPT for permanent teeth affected by caries lesions or trauma. Pulp diagnosis relies on clinical signs, symptoms, and pulp tests as well as radiographic assessment. Carious permanent teeth diagnosed with NP/RP are considered vital and can be treated with VPT. Irreversible pulpitis (**IP**) is the term used by the WG to categorize teeth from included studies that presented signs (radiographic) and/or symptoms (lingering thermal pain; throbbing, spontaneous, or referred pain) compatible with symptomatic irreversible pulpitis. Currently, there are five options for the treatment of caries lesions approximating the pulp in permanent teeth: (1) IPT (which notably includes selective caries removal); (2) DPC; (3) PP; (4) FP; and (5) root canal procedures.

When developing these guidelines, the overall combined clinical and radiographic success of VPT was evaluated to determine treatment success. Factors influencing VPT success, such as preoperative pain, caries lesion depth, radiographic preoperative periapical involvement (**PPI**), caries removal method, choice of pulp medicament/liner, and pulp therapy techniques, were evaluated for their impact on the overall success of VPT. Additionally, outcome moderators, such as the reason for pulp exposure (caries or trauma), type of pulp irrigation solution (saline/sodium hypochlorite [**NaOCl**]), time required to achieve hemostasis, and other factors, were assessed.

Statement of changes. This is the first clinical practice guideline exclusively dedicated to vital pulp therapy in permanent teeth developed by the AAPD. This document supersedes the 2025 recommendations for VPT for permanent teeth in the AAPD's *The Reference Manual of Pediatric Dentistry* best practice entitled "Pulp Therapy for Primary and Immature Permanent Teeth."[2]

Guideline development by the workgroup. The WG, approved by the AAPD Board of Trustees, met virtually and

GLOSSARY – CONTINUED

Reversible pulpitis (RP) clinical diagnosis indicating the tooth's pulp is inflamed yet capable of healing with proper treatment.

Randomized controlled trials (RCTs) are studies that use random assignment for groups of participants to compare their treatment successes.

Selective caries removal is indicated for deep caries. It is defined as incomplete removal of carious tissue to soft dentin or leathery dentin only on the pulpal aspect of the cavity, while peripheral carious dentin is completely removed to hard dentin.

Symptomatic irreversible pulpitis (SIP) is a clinical diagnosis indicating that the vital inflamed pulp can exhibit spontaneous, unprovoked pain, lingering thermal pain, or referred pain and may have periapical involvement.

Soft dentin is dentin that can be easily removed with minimum resistance using hand instruments.

Systematic review (SR) is a reproducible, complete review of existing studies or topics focused on a PICOS question. In this guideline, SR refers to the related data and figures as published in the journal *Pediatric Dentistry*.[1]

Stepwise caries removal is defined as being completed in two appointments. At the first appointment, selective removal of soft dentin is performed while the peripheral carious dentin is completely removed to hard dentin. A temporary filling is then placed at this appointment. At a second appointment months later, caries removal to firm dentin is completed, followed by placement of a long-term restoration.

Vital pulp therapy (VPT) encompasses evidence-based alternative approaches to managing teeth diagnosed preoperatively with either normal or inflamed vital pulps.

in-person between October 2022 and January 2025. The process of guideline development began by defining the population, interventions, comparisons, outcomes, and study designs (PICOS) of articles to be reviewed and assessed. A comprehensive list of relevant clinical questions was compiled before initiating a systematic review of all articles on VPT that met the inclusion criteria. The WG published the results of the SR[1] and then utilized those findings to develop these evidence-based recommendations.

Methods

The authors completed the systematic review concerning VPT through June 2024. This review included teeth diagnosed as having NP/RP or IP. The SR analyzed 388 articles. Both randomized and nonrandomized controlled trials, as well as in vitro studies, were reviewed. The authors defined treatment success as the patient concurrently experiencing no pain, exhibiting no clinical signs or symptoms of infection, and showing no postoperative radiographic pathology associated with the treated tooth. The SR provided meta-analyses and data from which the clinical recommendations, as well as the level of strength and certainty of evidence for each recommendation, were derived. A decision tree figure was developed based on the evidence-based recommendations to assist clinicians in selecting the recommended pulp therapies.

Important definitions. **Deep caries** is defined as lesions extending to the inner third or quarter of the dentin but showing a distinct radiographic zone of dentin over the pulp.[3] **Extremely deep caries** is defined as penetrating the full thickness of the dentin, with no discernible radiographic dentin barrier, indicating that a pulp exposure would be unavoidable based on radiographic views of occlusal or proximal caries.[3] **Soft dentin** is dentin that can be easily removed with minimum resistance using hand instruments. **Leathery dentin** does not deform when an instrument is pressed against it, can be easily lifted with minimal force, and exhibits a slight tackiness upon contact. **Firm dentin** is similar to leathery dentin in appearance but resists hand excavation and requires some pressure from the instrument to be lifted. **Hard dentin**, representing healthy, sound dentin, exhibits significant resistance to excavation and requires a sharp cutting edge or bur for removal.[4] **Selective caries removal** is indicated for deep caries. It is defined as removal to soft dentin or leathery dentin only on the pulpal aspect of the cavity, while peripheral carious dentin is completely removed to hard dentin.[5] **Stepwise caries removal** is defined as being done in two appointments. At the first appointment, selective removal of soft dentin is performed while the peripheral carious dentin is completely removed to hard dentin. A temporary filling is placed at this appointment. At a second appointment six to 12 months later, caries removal to firm dentin is completed, followed by placement of a well-sealed long-term restoration.[6] **Complete (nonselective) caries removal** is defined as removing all carious tissue, including all demineralized dentin to reach hard dentin, leaving no soft or leathery dentin.[6] The SR in this guideline refers to the data and figures published in the *Pediatric Dentistry* article titled "Vital Pulp Therapy in Permanent Teeth: A Systematic Review and Meta-Analyses."[1] CS are dental cements made from a composition of calcium and silicate. The types of CS evaluated for VPT procedures in this guideline were tricalcium and/or dicalcium silicate cements.

Search strategy and evidence inclusion criteria. It was decided a priori to use the findings of the AAPD's SR and meta-analyses on VPT in permanent teeth[1] as the evidence for this guideline's recommendations. The WG used the SR's multiple literature searches in MEDLINE/PubMed®, Ovid MEDLINE®, Epub Ahead of Print, MEDLINE In-Process & Other Non-Indexed Citations, Daily and Versi®, EMBASE, *Clinicaltrials.gov*, Dissertations and Theses-Global, Cochrane Library, and OpenGrey to identify randomized controlled trials (**RCTs**), nonrandomized studies, and systematic reviews addressing peripheral issues possibly not covered by the SR, such as patient preferences and impact of cost. The SR involved title, abstract, and full-text review of studies, which were reviewed independently by pairs of WG members. The assigned members extracted data and performed the risk of bias assessment (**ROB**) and meta-analyses, while the certainty of evidence was finalized by the WG.

Assessment of evidence. Several pertinent outcomes (eg, clinical, radiographic, and overall success of VPTs; success of caries removal approaches; reduction in microbial load; adverse events) were assessed. The certainty of the evidence was assessed using the Grade of Recommendation Assessment, Development, and Evaluation (**GRADE**) approach.[7] The GRADE approach recognizes the certainty of evidence as high, moderate, low, and very low based on serious or very serious issues, including the risk of bias, imprecision, inconsistency, indirectness of evidence, and publication bias. The WG evaluated and obtained consensus on the certainty of evidence for each studied outcome. The WG also discussed the available research on values and preferences to reach an agreement on the importance of various outcomes. These outcomes were factored into the evidence-to-decision framework to formulate clinical recommendations. Weaknesses of this guideline are inherent to the limitations found in the SR upon which this guideline is based.[1] Limitations include failure to review non-English language studies other than those in Spanish, Portuguese, and Chinese, and the recommendations are based on data from studies of different ROBs.

Formulation of recommendations and certainty. This clinical practice guideline presents recommendations for VPTs in permanent teeth. The WG evaluated various factors, including

treatment comparisons, the quantity and type of studies, the quality of evidence, the net benefit (considering potential harm versus benefit), resource implications (such as costs and training), and patient considerations. The number needed to treat (NNT) metric, measuring the number of patients/teeth needed to receive the recommended intervention to see a beneficial outcome, was used to provide clinicians with an estimate of the effectiveness of one treatment compared to an alternative one. The WG concluded that a low NNT value (eg, 10 or fewer) signifies a preferred treatment option. In developing the recommendations, the WG employed an evidence-to-decision framework that assessed criteria such as the priority of the clinical issue, the certainty of the evidence, the balance of desirable versus undesirable outcomes, patient values and preferences, acceptability, and feasibility.

The clinical recommendations were subjected to a structured guideline development process per the AGREE II tool.[8] The strength of each recommendation was classified as either strong or conditional, each carrying distinct implications for patients, clinicians, and policy (Table 1). Formulation of the recommendations involved teleconferences, in-person meetings, and online discussions among WG members. All recommendations and pertinent issues were thoroughly deliberated, and, if necessary, the WG voted to achieve a consensus of greater than 70 percent.

Understanding the recommendations. The evidence-based recommendations are designed to assist clinicians, patients/parents, and policymakers in making informed decisions regarding the application of various VPT interventions for the treatment of permanent teeth affected by deep caries. The interpretations of the strength of recommendations outlined in this guideline are detailed in Table 2. It is important to note that these recommendations do not supplant clinical judgment. A strong recommendation in favor of a particular intervention indicates that the WG is confident that the anticipated benefits outweigh any adverse effects, suggesting that clinicians should generally adhere to the recommended intervention. Conversely, a strong recommendation against an intervention signifies that the WG believes the potential adverse effects outweigh any possible benefits, advising clinicians against the use of that intervention in most circumstances. A conditional recommendation in favor suggests uncertainty regarding whether the positive effects surpass the negative outcomes, indicating that clinicians may consider

Table 1. GRADE INTERPRETATION OF STRENGTH OF RECOMMENDATIONS

Implications	Strong recommendations	Conditional recommendations
For patients	Most individuals in this situation would want the recommended course of action, and only a small proportion would not.	The majority of individuals in this situation would want the suggested course of action, but many would not.
For clinicians	Most individuals should receive the recommended course of action. Adherence to this recommendation according to the guideline could be used as a quality criterion or performance indicator. Formal decision aids are not likely to be needed to help individuals make decisions consistent with their values and preferences.	Recognize that different choices will be appropriate for different patients, and that you must help each patient arrive at a management decision consistent with their values and preferences. Decision aids may well be useful in helping individuals make decisions consistent with their values and preferences. Clinicians should expect to spend more time with patients when working toward a decision.
For policymakers	The recommendation can be adapted as policy in most situations, including for the use as performance indicators.	Policymaking will require substantial debates and the involvement of many stakeholders. Policies are also more likely to vary between regions. Performance indicators would have to focus on the fact that adequate deliberation about the management options has taken place.
GRADE certainty in the evidence		
High	We are very confident that the true effect lies close to that of the estimate of the effect.	
Moderate	We are moderately confident in the effect estimate. The true effect is likely to be close to the estimate of the effect.	
Low	Our confidence in the effect estimate is limited.	
Very low	We have very little confidence in the effect estimate.	

Table 2. GRADE INTERPRETATION OF STRENGTH OF RECOMMENDATIONS

Implications	Strong recommendations in favor	Strong recommendations against	Conditional recommendations in favor	Conditional recommendations against
For patients	There is confidence the desired benefits of the intervention outweigh any undesirable effects.	There is confidence the undesired effects of the intervention clearly outweigh any potential benefits.	There is uncertainty about whether the positive effects outweigh the negative results.	There is confidence that the undesired effects of the intervention likely outweigh any potential benefits.
For clinicians	Clinicians should follow the suggested recommendation.	In most situations, clinicians should not choose that intervention.	The clinician may want to follow a course of treatment while being aware that there are other more successful treatment choices for the individual patient.	A conditional recommendation against means the pulp therapy work group concluded there are other recommendations the clinician and patient should consider.

this treatment option while being cognizant of potentially more effective alternatives for the individual patient. A conditional recommendation against implies that the adverse effects likely outweigh the benefits, leading the WG to recommend that clinicians and patients explore other options. A summary of the recommendations, including their strength and the certainty of evidence, is presented in Tables 3 through 6. The WG has also developed an evidence-based decision tree on pulp therapies for permanent teeth that aims to support clinicians in their chairside decision-making (Figure).

A recommendation statement using "should" indicates a highly desirable treatment, while a recommendation phrased with "may" or "could" suggests an option or choice to pursue an alternative approach.

Exceptions to the guideline recommendations. Treatment plans may have to be adjusted or modified from the current recommendations due to the patient's ability to cooperate or complex medical and/or special needs. Other exceptions include need for advance behavior guidance techniques (protective stabilization, sedation, general anesthesia) and may include the inability to achieve profound local anesthesia, lack of tooth

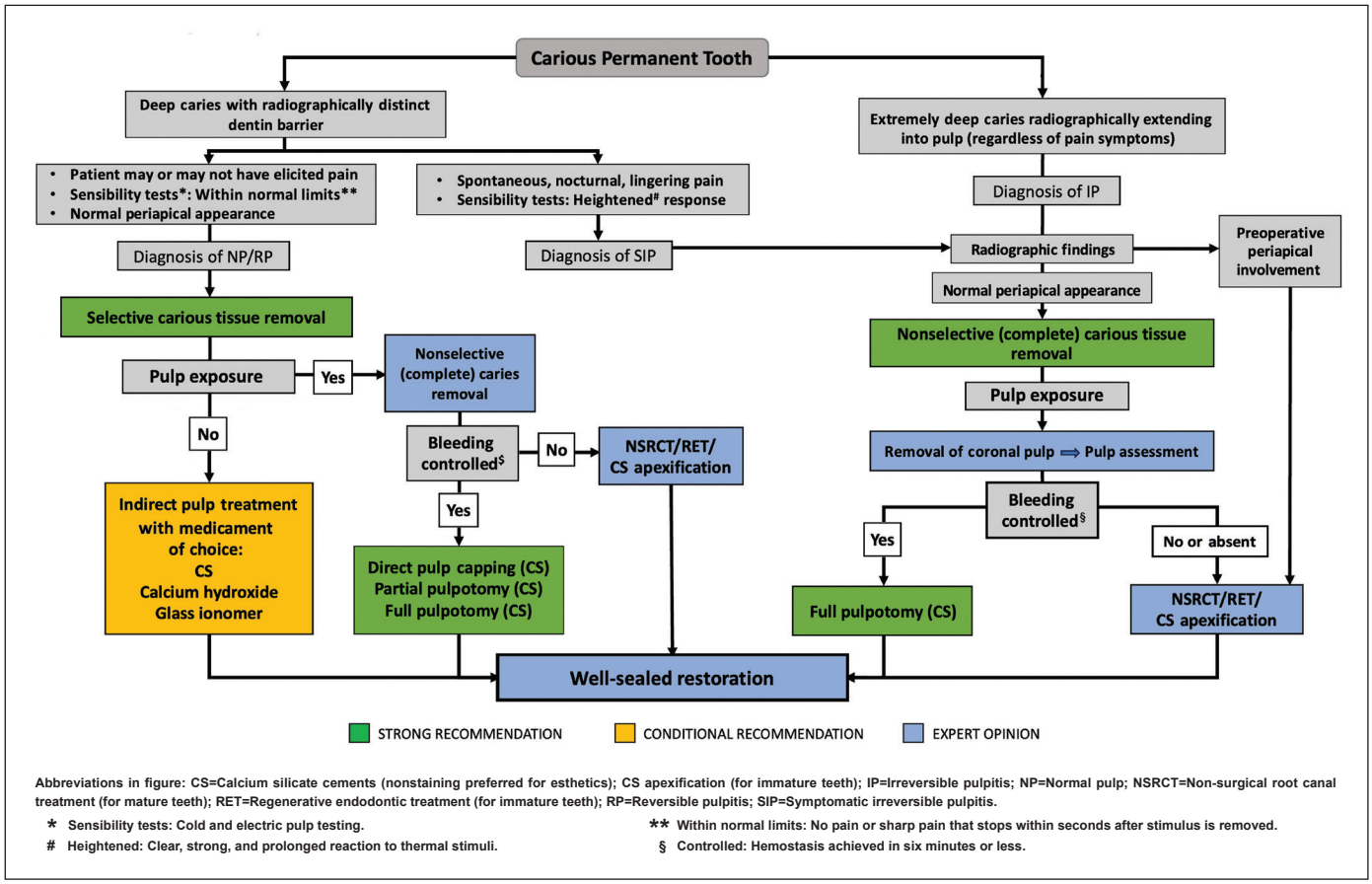
Table 3. AMERICAN ACADEMY OF PEDIATRIC DENTISTRY EVIDENCE-BASED RECOMMENDATIONS ON VITAL PULP THERAPIES (VPT) IN PERMANENT TEETH*

		Strength in favor of recommendation	Certainty of evidence (follow-up duration)
Preoperative pain and diagnosis			
Clinical question #1	***Which is currently the most-reliable method to diagnose pulp status in permanent teeth?***		
Recommendation	Clinicians may use cold and electric pulp testing in conjunction with clinical signs, symptoms, and radiographs when appropriate to establish a pulpal diagnosis.	Conditional	Very low certainty
Choice of vital pulp therapy			
Clinical question #2	***In permanent teeth with moderate to deep caries and diagnosed as having normal pulp or reversible pulpitis (NP/RP), which VPT (indirect pulp treatment [IPT], direct pulp capping [DPC], partial pulpotomy [PP], or full pulpotomy [FP]) has better success?***		
Recommendation	In permanent teeth with moderate to deep caries and diagnosed as having NP/RP, there is no significant difference in the success among IPT, DPC, PP, and FP at 24 months. Clinicians may choose a VPT based on the clinical presentation, their clinical expertise, and shared decision-making with the patient.	Conditional	Low certainty–24 months
Clinical question #3	***In permanent teeth undergoing selective caries removal, does the choice of medicament for IPT affect success?***		
Recommendation	The 24-month success of IPT is not altered significantly when choosing the IPT medicament. Clinicians may use glass ionomer cement, calcium hydroxide, or calcium silicate cement (CS) as the IPT medicament.	Conditional	Moderate certainty–24 months
Clinical question #4	***For teeth with deep caries and a diagnosis of NP/RP, is IPT or DPC treatment recommended?***		
Recommendation	In permanent teeth with deep caries and diagnosis of NP/RP, clinicians may perform IPT or, in case of pulp exposure, DPC using CS as both have similar success.	Conditional	Moderate certainty–36 months
Clinical question #5	***In permanent teeth with carious pulp exposures and diagnosis of NP/RP, is there a difference in 24-month success performing PP or DPC when utilizing CS?***		
Recommendation	For a carious pulp exposure in permanent teeth diagnosed as having NP/RP, PP is preferred over DPC unless CS is used for DPC, which then exhibits similar success.	Conditional	Low certainty–24 months
Clinical question #6	***Is there a difference in 24-month success performing PP or FP for carious pulp exposures utilizing CS in permanent teeth diagnosed with NP/RP?***		
Recommendation	For a carious pulp exposure in permanent teeth diagnosed as having NP/RP, PP or FP can be performed using CS based on their comparable 24-month success.	Conditional	Low certainty–24 months
Clinical question #7	***In permanent teeth exhibiting spontaneous, nocturnal, or lingering pain, is PP or FP preferred based on their 24-month success utilizing CS?***		
Recommendation	For permanent teeth exhibiting spontaneous, nocturnal, or lingering pain, FP may be preferred over PP due to its higher success at 24 months using CS.	Conditional	Low certainty–24 months
Clinical question #8	***For permanent teeth with evidence of irreversible pulpitis (IP) and exhibiting preoperative periapical involvement due to infection or uncontrolled pulpal bleeding, is pulpotomy an appropriate treatment option?***		
Recommendation	Pulpotomy is not indicated in permanent teeth diagnosed as having IP and exhibiting uncontrolled bleeding or preoperative periapical involvement due to infection.	Strong	Moderate certainty–60 months
Clinical question #9	***In vital permanent teeth with NP/RP sustaining a traumatic pulp exposure, which VPT should be used: PP or DPC?***		
Recommendation	In vital permanent teeth with NP/RP and a traumatic pulp exposure, PP/FP is recommended over DPC due to a significantly higher success rate.	Conditional	Low certainty–18 to 24 months

* Shared decision-making to prioritize therapies was determined by the pulp therapy work group to combine the effectiveness of the therapy, patient values and preferences, resources to be used, acceptability, and feasibility. No prioritization was assigned to the listed agents.

restorability, limited oral opening, severe gag reflex, facial swelling, an unclear diagnosis, complications from prior pulp therapy, or concurrent periodontal problems. In addition, esthetics, parent and patient preferences, and financial concerns may alter treatment decisions that may not conform to this guideline.

External review. The recommendations drafted by the WG were disseminated to external stakeholders (see the Disclosure statement). They were also sent to the AAPD's Council on Clinical Affairs, Council on Scientific Affairs, and Evidence-Based Dentistry Committee for review and comments or suggestions.



Abbreviations in figure: CS=Calcium silicate cements (nonstaining preferred for esthetics); CS apexification (for immature teeth); IP=Irreversible pulpitis; NP=Normal pulp; NSRCT=Non-surgical root canal treatment (for mature teeth); RET=Regenerative endodontic treatment (for immature teeth); RP=Reversible pulpitis; SIP=Symptomatic irreversible pulpitis.

* Sensibility tests: Cold and electric pulp testing.
** Within normal limits: No pain or sharp pain that stops within seconds after stimulus is removed.
\# Heightened: Clear, strong, and prolonged reaction to thermal stimuli.
§ Controlled: Hemostasis achieved in six minutes or less.

Figure. Pulp therapies decision tree for management of permanent teeth with deep/extremely deep caries.

Table 4. CARIOUS TISSUE REMOVAL TECHNIQUES*

		Strength in favor of recommendation	Certainty of evidence (follow-up duration)
Clinical question #10	*In permanent teeth with deep caries and a diagnosis of normal pulp or reversible pulpitis (NP/RP), which carious tissue removal method is recommended?*		
Recommendation	For permanent teeth with deep caries and a diagnosis of NP/RP, selective removal of caries is recommended over nonselective caries removal, due to fewer pulp exposures, and over stepwise caries removal, due to its higher 60-month success, reduction in pulp exposure incidence, and the advantage of being completed in one visit.	Strong	High certainty–60 months
Clinical question #11	*In vital permanent teeth having a normal radiographic appearance and deep caries with symptoms of spontaneous, nocturnal, or lingering pain, or radiographic appearance of extremely deep dental caries with or without these symptoms, what is the recommended approach for carious tissue removal?*		
Recommendation	Nonselective removal of carious tissue is recommended over selective or stepwise removal in vital permanent teeth exhibiting a radiographic appearance of deep caries with symptoms of spontaneous, nocturnal, or lingering pain, or exhibiting a radiographic appearance of extremely deep caries. Using nonselective excavation will lead to pulp exposure and thereby allow assessment of the exposed pulp's status.	Strong	Moderate certainty–24 to 60 months

* Shared decision-making to prioritize therapies was determined by the pulp therapy work group to combine the effectiveness of the therapy, patient values and preferences, resources to be used, acceptability, and feasibility. No prioritization was assigned to the listed agents.

The American Association of Endodontists (**AAE**) was solicited and returned comments and suggestions to this guideline. Revisions were made by the WG in response to the feedback received. This guideline reflects the external stakeholders' and AAPD's suggestions that culminated in the production of the final version of the recommendations.

Table 5. CHOICE OF PULP THERAPY MEDICAMENTS/IRRIGATION SOLUTIONS*

		Strength in favor of recommendation	Certainty of evidence (follow-up duration)
Clinical question #12	***In permanent teeth with normal pulp or reversible pulpitis (NP/RP), is direct pulp capping (DPC) success for carious pulp exposures affected by the choice of medicament?***		
Recommendation	For permanent teeth with NP/RP and deep caries lesions treated with DPC, calcium silicate cement (**CS**) significantly improves treatment success and is thereby recommended over calcium hydroxide [$Ca(OH)_2$] medicaments.	Strong	Moderate certainty–36 months
Clinical question #13	***Which irrigation solution is recommended, based on success, when performing DPC?***		
Recommendation	Sodium hypochlorite (**NaOCl**) irrigation and cotton pellets soaked with it are recommended because NaOCl significantly increases DPC success over a period of 36 to 42 months compared to the use of saline.	Strong	Moderate certainty–36-42 months
Clinical question #14	***In permanent teeth with deep caries with a diagnosis of NP/RP, or irreversible pulpitis undergoing pulpotomy, does the choice of irrigation solution improve success?***		
Recommendation	The use of NaOCl irrigation and cotton pellets soaked with NaOCl for hemostasis during pulpotomy is suggested over the use of saline.	Conditional	Very low–12 to 42 months

* Shared decision-making to prioritize therapies was determined by the pulp therapy work group to combine the effectiveness of the therapy, patient values and preferences, resources to be used, acceptability, and feasibility. No prioritization was assigned to the listed agents.

Table 6. VITAL PULP THERAPY TECHNIQUES/RESTORATIONS/MODERATORS*

		Strength in favor of recommendation	Certainty of evidence (follow-up duration)
Clinical question #15	***Which is the preferred isolation method when performing vital pulp therapy (VPT)?***		
Recommendation	The use of a rubber dam for VPT is regarded as the gold standard and is critical for maintaining isolation and preventing contamination from saliva, blood, and other substances.		
Clinical question #16	***Does the use of magnification help to determine the suitability for VPT in permanent teeth?***		
Recommendation	The use of magnification is likely to enhance the visualization of the pulp, allowing assessment of the pulpal status.		
Clinical question #17	***What are the effects of the type and timing of the final restoration on VPT success?***		
Recommendation	The effect of timing or type of final restoration on the success of VPT could not be conclusively determined. To reduce the risk of coronal leakage, the WG recommends the use of a well-sealed restoration, preferably at the same visit.		
Clinical question #18	***Does the status of root maturation in permanent teeth with deep caries and a diagnosis of normal pulp or reversible pulpitis (NP/RP) influence the success of pulpotomy?***		
Recommendation	The status root maturation does not significantly affect the success of either partial or full pulpotomy performed with calcium silicate cement (**CS**) in permanent teeth and a diagnosis of NP/RP.	Conditional	Low certainty–24 months
Clinical question #19	***Which CS should be used for permanent teeth in esthetic areas to prevent tooth discoloration?***		
Recommendation	The use of nonstaining CS is recommended in esthetic areas of permanent teeth to prevent tooth discoloration.	Strong	High certainty–12-24 months
Clinical question #20	***What is the recommended time limit to achieve hemostasis during a pulpotomy procedure in permanent teeth to ensure successful treatment outcomes?***		
Recommendation	It is recommended to perform partial or full pulpotomy when hemostasis can be achieved in 6 minutes or less as the success is likely to be higher.	Conditional	Low certainty–12-24 months
Clinical question #21	***Does the location of caries in permanent teeth influence the success of VPT procedures?***		
Recommendation	There was insufficient data to make a recommendation regarding the effect of caries location on the success of VPT.		

* Shared decision-making to prioritize therapies was determined by the pulp therapy work group to combine the effectiveness of the therapy, patient values and preferences, resources to be used, acceptability, and feasibility. No prioritization was assigned to the listed agents.

Evidence-based recommendations

Preoperative pain and diagnosis

Clinical question #1. Which is currently the most-reliable method to diagnose pulp status in permanent teeth?

Recommendation: Clinicians may use cold and electric pulp testing in conjunction with clinical signs, symptoms, and radiographs when appropriate to establish a pulpal diagnosis. The strength of recommendation was conditional, and the certainty of this evidence was very low.

Summary of findings: The SR found laser Doppler flowmetry and pulse oximetry exhibit the highest accuracy for diagnosing pulp vitality; however, there are currently no commercial products available for use by clinicians. Among the commonly used pulp sensibility tests, cold testing and electric pulp testing combined demonstrate moderate to high diagnostic accuracy as indicators of the pulp's status. Clinicians may use cold and electric pulp testing as an adjunct to clinical signs and symptoms, as well as radiographs when appropriate. This conditional recommendation was assessed a very low certainty of evidence due to the use of three systematic reviews not done by the WG.

Choice of VPT (see Table 3)

Clinical question #2. In permanent teeth with moderate to deep caries and diagnosed as having NP/RP, which vital pulp therapy (IPT, DPC, PP, FP) has better success?

Recommendation: In permanent teeth with moderate to deep caries and diagnosed as having NP/RP, there is no significant difference in the success among IPT, DPC, PP, and FP at 24 months. Clinicians may choose a VPT based on the clinical presentation, their expertise, and shared decision-making with the patient. The recommendation strength was conditional, and the certainty of this evidence was low based on 24-month data.

Summary of findings: RCTs of low or unclear ROB were used in the SR to assess the overall success of various types of VPT. The success of different VPT procedures was evaluated in teeth diagnosed as having NP/RP. The indirect comparison of the SR's forest plot evaluated studies involving IPT, DPC, PP, or FP after 24 months, in which caries depth or type of caries removal method may or may not have been delineated. There was no statistically significant difference in the success of these for VPT procedures, which ranged from 91 to 97 percent (SR's Figure 2; *P*=0.19). The recommendation strength was conditional and characterized as low certainty due to this 24-month indirect comparison. Some studies[9,10] show that leaving dentin with caries is not detrimental to the pulp. Maltz et al. demonstrated the number of bacteria detected in permanent teeth after nonselective caries removal was higher than what remained after incomplete (selective) caries removal.[9] Other investigators found no significant difference between nonselective and selective caries removal and the number of bacteria detected in primary teeth after three to six months.[11]

Clinical question #3. In permanent teeth undergoing selective caries removal, does the choice of medicament for IPT affect success?

Recommendation: The 24-month success of IPT is not altered significantly when choosing the IPT medicament. Clinicians may use either glass ionomer cement (**GIC**), calcium hydroxide [**$Ca(OH)_2$**], or CS as the IPT medicament. The strength of this recommendation is conditional with a moderate certainty of evidence based on 24-month data.

Summary of findings: The IPT medicament liners were tested for their impact on the success of IPT. As reported in the SR, a direct comparison meta-analysis noted 24-month success of IPT was significantly improved using CS (*P*=0.02; SR's sFigure 12), but the NNT of 13 implied the clinical significance of this finding is limited. A 24-month indirect comparison forest plot using more studies compared CS use for IPT versus resin bonding, GIC, or $Ca(OH)_2$ revealed CS success (96 percent) was not significantly different from alternate liner success (90 percent; *P*=0.29; SR's sFigure 13). The SR also reported a direct comparison 24-month forest plot of GIC liner for IPT versus $Ca(OH)_2$. As seen in the SR's sFigure 14, the IPT success utilizing GIC was 95 percent versus 87 percent for $Ca(OH)_2$ (*P*=0.14; NNT equals 13).

Clinical question #4. For teeth with deep caries and a diagnosis of NP/RP, is IPT or DPC recommended?

Recommendation: In permanent teeth with deep caries and a diagnosis of NP/RP, clinicians may perform IPT or in case of pulp exposure, DPC using CS as both have similar success. The strength of this recommendation is conditional with a moderate certainty of evidence based on 36-month data.

Summary of findings: An indirect comparison of data from different studies evaluated the success of DPC versus IPT after 36 months was presented in the SR. For the DPC group, only teeth with pulp exposures that had moderately deep caries (≥50 percent of the dentin thickness) were included. All teeth were diagnosed with NP or RP. Based on the SR's Figure 3, DPC success was 87 percent while IPT success was 94 percent (*P*=0.10). The DPC-treated teeth exclusively used CS as the DPC agent. The recommendation strength was conditional, and certainty was moderate due to using a 36-month indirect comparison. A 24-month indirect comparison of IPT and DPC success showed DPC success was 87 percent versus 92 percent for IPT (*P*=0.46, SR's sFigure 1). All teeth were diagnosed with NP and RP and had moderately deep caries as defined above. The number of bacteria detected in permanent teeth after nonselective caries removal was shown to be higher than what remained after selective caries removal following six to seven months of sealing with a temporary restoration.[9] Other investigators found no significant difference in the number of bacteria detected in primary teeth between nonselective and selective caries removal after three to six months.[11]

Remarks: The data in SR's Figure 3 used DPC-treated teeth with different caries depths. The success of IPT versus DPC would ideally compare teeth with identical caries depths.

Clinical question #5. In permanent teeth with carious pulp exposures and a diagnosis of NP/RP, is there a difference in 24-month success performing PP or DPC when utilizing CS?

Recommendation: For a carious pulp exposure in a permanent tooth diagnosed as having NP/RP, PP is preferred over DPC unless CS is used for DPC, which then exhibits similar success. The strength of this recommendation is conditional with a low certainty of evidence based on 24-month data.

Summary of findings: In the SR, an indirect comparison was conducted using pooled data from different studies comparing the success of DPC versus PP after 24 months. As seen in SR's Figure 4a, teeth with carious pulp exposures diagnosed with NP/RP showed a DPC success of 93 percent while PP success was 97 percent (*P*=0.25). The DPC success appeared to be lowered by including $Ca(OH)_2$ study arms as the DPC material. A second indirect plot only compared DPC study arms using CS. According to the sensitivity analysis in SR's Figure 4b, DPC and PP, when using CS, showed equal success rates of

96 percent (P=0.77). The SR concluded that PP would be preferred over DPC unless CS was used for DPC. The recommendation strength was conditional, and the certainty of evidence was low due to using a 24-month indirect comparison.

Clinical question #6. Is there a difference in 24-month success performing PP or FP for carious pulp exposures utilizing CS in permanent teeth diagnosed with NP/RP?

Recommendation: For a carious pulp exposure in permanent teeth diagnosed as having NP/RP, PP or FP can be performed using CS based on their comparable 24-month success. This recommendation strength is conditional with a low certainty of evidence.

Summary of findings: For teeth diagnosed with NP/RP, the SR conducted an indirect meta-analysis comparing PP and FP. All pulpotomies used CS as the medicament and were performed on teeth with deep caries but no traumatic pulp exposures. PP success after 24 months was 98 percent versus 94 percent for FP (P=0.44; SR's sFigure 2). The recommendation strength was conditional with a low certainty of evidence due to using a 24-month indirect comparison.

Clinical question #7. In permanent teeth exhibiting spontaneous, nocturnal, or lingering pain, is PP or FP preferred based on its 24-month success utilizing CS?

Recommendation: For permanent teeth exhibiting spontaneous, nocturnal, or lingering pain, FP may be preferred over PP due to its higher success at 24 months using CS. The strength of this recommendation is conditional with a low certainty of evidence based on 24-month data.

Summary of findings: The SR used a direct comparison of success of PP and FP after 12 months in teeth presenting with spontaneous, nocturnal, or lingering pain from caries. All pulpotomies were performed using CS medicaments. According to the direct comparison presented in SR's Figure 5a, FP exhibited higher success (97 percent) compared to PP (88 percent) based on 12-month data (P=0.24; NNT equals 12). A 24-month indirect comparison was made between PP and FP, with both pulpotomies using CS. The PP success equaled 88 percent while for FP it was 95 percent (P=0.34, SR's Figure 5b). For teeth diagnosed with IP, FP is preferred over PP based on the SR's finding. The strength of this recommendation is conditional with a low certainty due to the 24-month indirect comparison.

Remarks: The SR also reported a 12-month direct comparison that suggests FP success may be comparable to root canal treatment success in teeth with IP.

Clinical question #8. For permanent teeth with evidence of IP and exhibiting preoperative periapical involvement due to infection or uncontrolled pulpal bleeding, is pulpotomy an appropriate treatment option?

Recommendation: Pulpotomy is not indicated in permanent teeth diagnosed as having IP and exhibiting uncontrolled bleeding or PPI due to infection. This is a strong recommendation with a moderate certainty of evidence based on 60-month data.

Summary of findings: For teeth diagnosed with IP, one study reported a five-year success rate for FP using a CS of 78 percent (107 of 137).[12] The SR showed FP's five-year success was significantly better at 82 percent (84 of 102) in teeth without PPI compared to 66 percent in teeth with PPI (23 of 35; P=0.04; SR's sFigure 5). Taha et al.[13] and Uesrichai et al.[14] recommended that if early periapical infections were noted on radiographs or dental abscess infections exhibited radiographic changes, root canal procedures should be instituted. These studies also recommended performing root canal procedures if bleeding was not controlled within 10 minutes; however, based on the SR, higher PP and FP success rates were reported when bleeding was controlled within six minutes.[1]

Clinical question #9. In vital permanent teeth diagnosed with NP/RP sustaining a traumatic pulp exposure, which vital pulp treatment should be used, pulpotomy or DPC?

Recommendation: In vital permanent teeth diagnosed with NP/RP and a traumatic pulp exposure, PP/FP is recommended over DPC due to a significantly higher success rate. The strength of this recommendation is conditional with a low certainty of evidence based on 18- to 24-month data.

Summary of findings: An indirect comparison forest plot conducted in the SR evaluated the success rates of PP, FP, or DPC for traumatic pulp exposures after 18 to 24 months. The forest plot showed a success rate of 93 percent for PP and 89 percent for FP, while DPC achieved only a 43 percent success rate after 24 months, which was significantly lower (P<0.0001; SR's sFigure 19) The recommended treatment for traumatic pulp exposures is to use pulpotomy (partial or full), as it results in higher success after 18 to 24 months compared to DPC.

Carious tissue removal techniques (see Table 4)

Clinical question #10. In permanent teeth with deep caries and a diagnosis of NP/RP, which carious tissue removal method is recommended?

Recommendation: For permanent teeth with deep caries and a diagnosis of NP/RP, selective removal of caries is recommended over nonselective caries removal due to fewer pulp exposures and over stepwise caries removal due to its higher 60-month success, reduction in pulp exposure incidence, and the advantage of being completed in one visit. This is a strong recommendation with a high certainty of evidence.

Summary of findings: Different methods of carious tissue removal were evaluated in the SR's data to determine their effect on VPT success in teeth diagnosed with NP/RP. The SR reported on four studies that directly compared selective versus stepwise caries removal 12 months after VPT. A 12-month meta-analysis revealed no significant difference in success (P=0.17, SR's sFigure 7). Two studies[15,16] reported 60-month results using selective versus stepwise caries removal. Selective caries removal was utilized for IPT, resulting in a 78 percent success (136 of 175) versus stepwise success of 64 percent (102 of 159; P=0.27, NNT equals eight, SR's sFigure 8). The number of bacteria detected in permanent teeth after nonselective caries removal was higher than what remained after selective caries removal.[9] A 2024 systematic review, comparing nonselective to selective and stepwise caries removal using RCTs, concluded that nonselective was invasive and not highly recommended for deep caries.[17] An 18-month RCT comparing nonselective versus selective caries removal reported on 123 permanent teeth, for which pulp exposures were significantly increased using nonselective caries removal; however, there was no significant difference in pulpal treatment success.[4]

In the SR, a direct comparison showed that stepwise caries removal resulted in significantly fewer pulp exposures (17 percent) compared to nonselective caries removal (32 percent; P<0.001, SR's sFigure 9). Another direct comparison forest plot revealed that selective caries removal showed significantly fewer pulp exposures (10 percent) compared to nonselective removal (27 percent; P=0.002, SR's sFigure 10). In a third forest

plot, selective caries removal was directly compared to stepwise removal but showed no significant difference (P=0.11) in the incidence of pulp exposures. The pulp exposure incidence for selective caries removal equaled 0.05 percent compared to a stepwise incidence of 4.3 percent, as shown in the SR's sFigure 11. Teeth for which selective or stepwise caries removal was utilized had similar success rates, but selective caries removal results in fewer pulp exposures and has the advantage of the ability to be completed in one visit.

Clinical question #11. In vital permanent teeth having a normal radiographic appearance and deep caries with symptoms of spontaneous, nocturnal, or lingering pain or a radiographic appearance of extremely deep dental caries with or without these symptoms, what is the recommended approach for carious tissue removal?

Recommendation: Nonselective removal of carious tissue is recommended over selective or stepwise removal in vital permanent teeth exhibiting a radiographic appearance of deep caries with symptoms of spontaneous, nocturnal, or lingering pain or exhibiting a radiographic appearance of extremely deep caries. Using nonselective excavation will lead to pulp exposure and thereby allow assessment of the exposed pulp's status. This is a strong recommendation with a moderate certainty of evidence based on 24- to 60-month data.

Summary of findings: In teeth presenting with symptoms of spontaneous, nocturnal, or lingering pain, Schwendicke et al. recommended doing nonselective caries removal since it is essential to eliminate infected tissue.[10] According to Taha et al.,[13] nonselective caries removal should be used and, when the pulp is exposed, an intraoperative assessment of the pulpal wound should be performed. If the pulp exhibits hemorrhaging, bleeding control is necessary to consider VPT. If hemostasis cannot be achieved, root canal therapy should be considered.[13] The SR investigated this treatment concept in teeth diagnosed with IP. No DPC studies were found that included only teeth with IP as the preoperative diagnosis. The SR addressed teeth diagnosed as having IP (based on symptoms of spontaneous, nocturnal, or lingering pain) that were treated with nonselective caries removal for pulpotomy. When the pulp was exposed during caries removal, it was visualized to assess its vitality and the ability to achieve hemostasis. The SR's Figures 5a and 5b show FP with nonselective caries removal, when the exposed pulp was assessed as vital, had higher success than PP at 12 and 24 months (24-month FP success equals 95 percent; PP success equals 88 percent).

Remarks: Asgary et al. reported five-year findings in teeth diagnosed with IP that included teeth exhibiting symptoms of spontaneous, nocturnal, or lingering pain.[12] The caries removal method employed was nonselective, with a pulp vitality assessment after the pulp was exposed before the FP procedure. The SR[1] reported that Asgary et al.'s FP five-year success was significantly improved, showing 82 percent success (84 of 102) in teeth without PPI. The WG found no studies comparing selective or stepwise removal to complete removal for teeth with deep or extremely deep caries and exhibiting symptoms of s pontaneous, nocturnal, or lingering pain and normal periapical radiographic appearance. The certainty of evidence was determined to be moderate, given the high five-year success rate.

Choice of pulp therapy medicaments/irrigation solutions (see Table 5)

Clinical question #12. In permanent teeth with a diagnosis of NP/RP, is DPC success for carious pulp exposures affected by the choice of medicament?

Recommendation: For permanent teeth with a diagnosis of NP/RP and deep caries lesions treated with DPC, CS significantly improves treatment success and is thereby recommended over $Ca(OH)_2$ medicaments. This is a strong recommendation with a moderate certainty of evidence based on 36-month data.

Summary of findings: The SR included an indirect comparison meta-analysis that evaluated DPC success when using CS compared to $Ca(OH)_2$. The 36-month DPC success employing CS was 88 percent versus 70 percent for $Ca(OH)_2$ (P=0.003; SR's sFigure 15). In addition, the SR showed a sensitivity analysis directly comparing two DPC 36-month studies in teeth diagnosed with NP/RP. This analysis revealed DPC success was 85 percent when using mineral trioxide aggregate (**MTA**) versus 69 percent when using $Ca(OH)_2$. Although the P-value for this meta-analysis was 0.16, it also exhibited a clinically significant NNT of seven (SR's sFigure 16). Overall, these meta-analyses demonstrated that performing DPC with CS resulted in a clinically significant increase in success after 36 months compared to $Ca(OH)_2$ use.

Clinical question #13. Which irrigation solution is recommended, based on success, when performing DPC?

Recommendation: NaOCl irrigation and cotton pellets soaked with it are recommended because NaOCl significantly increases DPC success over a period of 36 to 42 months compared to the use of saline. This is a strong recommendation with a moderate certainty of evidence based on 36- to 42-month data.

Summary of findings: The SR reported on 36- to 42-month DPC success data that compared a normal saline-moistened pellet versus NaOCl irrigation or moistened pellet to disinfect and achieve pulpal hemostasis. This analysis was based on an indirect comparison of data for DPC success in teeth diagnosed with NP/RP. The DPC success was significantly higher utilizing NaOCl compared to saline (P=0.02). Specifically, the DPC success with saline was 67 percent, while NaOCl demonstrated a significantly improved success rate of 83 percent (SR's sFigure 21). Even though it is an indirect comparison with high heterogeneity, the level of certainty was upgraded to moderate due to the magnitude of the effect and long-term follow-up.

Clinical question #14. In permanent teeth with deep caries with a diagnosis of NP/RP or IP undergoing pulpotomy, does the choice of irrigation solution affect success?

Recommendation: The use of NaOCl irrigation and cotton pellets soaked with NaOCl for hemostasis during pulpotomy is suggested over the use of saline. The strength of recommendation is conditional with a very low certainty.

Summary of findings: The SR reported an indirect 24-month comparison of PP treatment using a dry or water- or saline-moistened cotton pellet versus NaOCL irrigation or moistened pellet. This comparison showed the success of PP using water/saline was 91 percent compared to NaOCl's 96 percent success (P=0.16; SR's sFigure 22). The success of FP procedures, all of which utilized CS, employing different irrigation methods and agents could only be compared indirectly for 12 months. Since there is insufficient data for pulpotomies, the WG utilized the DPC data noted in clinical question #13 as an indirect comparison

of evidence to make the recommendation. The strength of recommendation was conditional with a very low certainty of evidence.

Vital pulp therapy techniques/restorations/moderators (see Table 6)

Clinical question #15. Which is the preferred isolation method when performing VPT?

Recommendation: The use of a rubber dam for VPT is regarded as the gold standard and is critical for maintaining isolation and preventing contamination by saliva, blood, or other substances.

Summary of findings: Most studies included in the SR used a rubber dam for isolation of teeth when the clinicians performed VPT. No data compared the use of a rubber dam to non-use influencing the success of VPT.

Clinical question #16. Does the use of magnification help to determine the suitability for VPT in permanent teeth?

Recommendation: The use of magnification is likely to enhance the visualization of the pulp, allowing assessment of the pulpal status.

Summary of findings: The SR reported there were no RCT data directly comparing magnification use to no magnification on VPT success. The SR found recent RCTs are addressing the use of enhanced magnification when performing VPT, although none of these studies indicated it improved VPT success. The SR reported it seemed likely that the use of magnification would aid in the proper visualization of the exposed pulp.

Clinical question #17. What are the effects of the type and timing of the final restoration on VPT success?

Recommendation: The effect of the timing or type of final restoration on the success of VPT could not be conclusively determined. To reduce the risk of coronal leakage, the WG recommends the use of a well-sealed restoration, preferably at the same visit as the VPT.

Summary of findings: The SR's data comparing the time of placement of the final restoration on the day of VPT versus one day or weeks later was inconclusive. Most studies reporting placement of final restorations after the day of VPT did not consistently specify the number of days elapsed before the final restoration was placed. The various types of final restorations could not be categorized to evaluate their effect on VPT success; however, they were generally well-sealed restorations.

Clinical question #18. Does the status of root maturation in permanent teeth with deep caries and a diagnosis of NP/RP influence the success of pulpotomy?

Recommendation: The status of root maturation does not significantly affect the success of either PP or FP performed with CS in permanent teeth with deep caries and a diagnosis of NP/RP. This is a conditional recommendation with a low certainty of evidence based on 24-month data.

Summary of findings: The SR assessed the success of PP/FP using CS in immature versus mature rooted teeth. The SR reported a 24-month success for teeth diagnosed with NP/RP based on an indirect comparison meta-analysis. The findings indicated the success rate of PP/FP for immature teeth was 98 percent versus 92 for mature teeth (P=0.11; SR's sFigure 20).

Clinical question #19. Which CS should be used for permanent teeth in esthetic areas to prevent tooth discoloration?

Recommendation: The use of nonstaining CS is recommended for permanent teeth in esthetic areas to prevent tooth discoloration. This is a strong recommendation with a high certainty of evidence after 12 to 24 months.

Summary of findings: The SR reported that CS without bismuth oxide and other similar agents produces significantly less discoloration than traditional materials and, therefore, may be preferred in esthetic and visible areas. In the SR, two different CS preparations (MTA and Biodentine™ [Septodont]) were evaluated in clinical studies for tooth discoloration. MTA contains bismuth oxide, whereas Biodentine™ does not. The SR examined tooth discoloration data after 12 to 24 months on teeth treated with MTA or Biodentine™. The teeth in these studies were treated with DPC, PP, or FP. The SR's findings indicated MTA-treated teeth exhibited 83 percent discoloration, while no discoloration was observed in the Biodentine™-treated teeth (P<0.0001, SR's sFigure 18).

Clinical question #20. What is the recommended time limit to achieve hemostasis during a pulpotomy procedure in permanent teeth to ensure successful treatment outcomes?

Recommendation: It is recommended to perform partial or full pulpotomy when hemostasis can be achieved in six minutes or less as the success is likely to be higher. This is a conditional recommendation with a low degree of certainty after 12 to 24 months.

Summary of findings: The SR reported a mean time of 4.25 minutes to achieve hemostasis for PP. The SR also described FP studies in which the time to stop pulpal bleeding ranged from 4.25 to 5.78 minutes. The SR concluded pulpotomy success was higher when hemostasis was achieved in six minutes or less.

Clinical question #21. Does the location of caries in permanent teeth influence the success of VPT?

Recommendation: There was insufficient data to make a recommendation regarding the effect of caries location on the success of VPT.

Research implications

This guideline recommends further research into methods for diagnosing the pulp's status in permanent teeth. It is disappointing that the SR found insufficient evidence on methods used to accurately diagnose the pulp's status in permanent teeth with caries. Future research on pulpal diagnosis should focus on (1) using consistent methodology to study laser Doppler flowmetry and pulse oximetry, and (2) making these technologies clinically usable.

At the time of this guideline's publication, a patient with a permanent tooth exhibiting spontaneous pain, lingering thermal pain, or referred pain is diagnosed with symptomatic irreversible pulpitis (**SIP**) according to the AAE's *Glossary of Endodontic Terms*.[5] Part of the SIP definition indicates that the inflamed pulp is incapable of healing. This guideline strongly recommends, with moderate certainty, that a vital pulpotomy using CS be performed on any carious permanent teeth with SIP, provided they have a normal periapical radiographic appearance. The definitions of pulpitis need to be revised to reflect the continuum of a pulp's inflammation and its capacity to heal in the presence of favorable conditions. Further research is needed to determine the parameters of when pulpotomy is indicated for SIP. CS materials have been utilized successfully for pulpotomy

in permanent teeth diagnosed with SIP when pulpal hemorrhage can be controlled and periapical radiographic appearance is normal. Potentially, pulpotomy could prevent the need for extraction or pulpectomy procedures in permanent teeth with certain SIP diagnoses.

For deep caries lesions in vital permanent teeth, the American Dental Association's guideline conditionally recommends selective carious tissue removal over stepwise carious tissue removal or nonselective carious tissue removal, though this recommendation is based on very low certainty evidence.[18] More definitively, this guideline strongly recommends selective caries removal of deep caries based on five-year data with high certainty (SR's sFigure 8). This recommendation contrasts with the AAE's position statement regarding caries removal in teeth diagnosed with NP/RP and exhibiting deep caries, which states "predictable management of vital pulp tissue should not be performed without complete removal of both demineralized enamel and infected dentin."[19] This dichotomy of recommendations for treatment of deep caries in permanent teeth necessitates a critical review of the evidence-based research.

Developing reliable biomarkers to accurately assess the level of inflammation within the pulp is crucial. These biomarkers will significantly improve treatment decision-making. To effectively diagnose and treat pulp inflammation, there is a need to delve deeper into pharmacological inhibition by exploring medications that suppress inflammation; stem cell applications by investigating the use of stem cells to regenerate damaged pulp tissue; andimmunotherapy by exploring treatments that modulate the immune response to reduce inflammation.

Long-term research extending beyond 24 months is needed to evaluate other CS materials, rather than just MTA and Biodentine™, used in VPT. It is important to determine whether these materials are equally or more effective than MTA and Biodentine™. Additionally, studies are needed to assess whether the success of VPT differs in permanent teeth with proximal caries versus occlusal caries.

Furthermore, research should focus on the timing and type of final restorations that effectively seal the VPT to maximize the pulp treatment's success. The use of artificial intelligence is an emerging science and may be applied to analyze data and personalize treatment plans. Its use for improving the accuracy of pulpal diagnosis and case selection of VPT procedures should be undertaken using RCTs.

The WG did not identify any studies that evaluated whether VPT had any indications for use in medically compromised patients. There is no data to indicate if VPT could adversely affect the overall health status of these patients. The WG could not make any treatment recommendations for asymptomatic IP due to the PICOS search terms.

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Disclosure. External stakeholders: American Dental Association, American Association of Endodontists, International Association of Endodontists, International Association of Paediatric Dentistry, National Network for Oral Health Access.

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