Review Article

Vital Pulp Therapy

Immature Permanent Teeth and Vital Pulp Therapy, Complete Caries Removal Versus Stepwise Excavation: A Review of Literature

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ABSTRACT

Objective: This article reviews the literature pertaining to vital pulp therapy in immature permanent teeth with a focus on comparing two specific methods of caries removal. The significance, objectives, treatment options, indications, and outcomes of pulp capping and pulpotomy were discussed.

Study Design: Literature Review

Place and Duration of Study: This study was conducted at the College of Dentistry, Qassim University, Saudi Arabia from April to October 2020.

Materials and Methods: The PICO framework was used to formulate the research question. The search was conducted using specific MeSH terms and/or keywords related to 'vital pulp, 'pulpotomy' and 'permanent teeth'. The databases searched were Ovid MEDLINE and EMBASE, and EBM Reviews or Cochrane Central Register of Controlled Trials.

Results: Results were obtained after removing duplicates and irrelevant articles based on defined inclusion criteria. From the 248 articles identified, 26 were eligible and included in the literature review. The articles concerned with vital pulp therapy in immature permanent teeth were reviewed and the articles were analyzed.

Conclusion: Immature permanent teeth have the best prognosis if their vitality is maintained. With careful case selection and aseptic techniques, pulp capping and pulpotomy are good treatment options for maintaining the vitality of these teeth.

Key Words: Pulp capping; pulpotomy; vital pulp therapy; permanent teeth.

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INTRODUCTION

Preservation of tooth vitality is one of the main aims of dental treatment and it is of particular significance in permanent teeth with immature roots.[1] These teeth present multiple challenges for adequate and successful root canal treatment such as difficulty in cleaning and obturating the canal requiring aggressive instrumentation and risk of overfilling, weakening of the root canal potentially leading to a compromised crown: root ratio, and weak roots which are highly susceptible to fracture[2,3]

Moreover, the long-term retention of permanent teeth with immature roots is generally lower than in those with fully developed roots.[4]

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Literature shows a higher incidence of cervical root fractures in endodontically treated immature teeth compared to teeth with fully mature roots. [5]

Maintenance of the health and integrity of the teeth' supporting structures is vital pulp therapy's main objective. The vitality of the pulp is maintained by promoting pulpal healing and the formation of tertiary or reparative dentin, facilitating apexogenesis or continued physiological root development, maturation, and apical closure.[6,7] Vital pulp therapy (VPT) is no longer limited to reversible pulpitis, instead, more evidence is being built in favor of VPT in teeth regardless of the signs and symptoms a patient experiences indicative of reversible or irreversible pulpitis.[8] The general consensus is that vital pulp therapy is successful in immature permanent teeth owing to a high potential for healing due to their wide open apices and rich blood supply.[9]

The possibility of preserving the vitality of a permanent tooth, regardless of the stage of root development, should be a clinician's primary concern when considering the management of deep caries or carious/traumatic pulp exposures. This decision, however, should be an educated one involving the careful weighing of the potential benefits and risks of the available treatment options.[10] Since, the loss of vitality of the pulp in immature permanent teeth has detrimental consequences, attempts should be made to

maintain the vitality of these teeth. However, pulpectomy and apexification are the treatment of choice in case the tooth is not a good candidate for vital pulp therapy.[11] Pulpectomy is the procedure to chemically and mechanically remove irreversibly inflamed or necrotic radicular tissue and followed by filling the root canal.[12] Apexification is a procedure for initiating the calcification in the radical area of a tooth with an open apex or the continuous apical development in incomplete roots having necrosed pulps..[13] Apical closure will occur, however, the root will remain thin, fragile, and prone to fracture.[14]

Controversy still exists regarding the optimum treatment option and type of pulp dressing providing the most predictable healing. It is difficult to predict the exact ability of the pulp to heal, particularly if the integrity of the pulp has been seriously compromised, therefore, close patient follow-up is essential.[15] This review aimed to review the various treatment options for treating immature permanent teeth.

MATERIALS AND METHODS

A broad search strategy was applied. This aimed to identify all the relevant published data with regard to the research questions and inclusion criteria used. The search strategy was developed for Ovid MEDLINE and was applied to other databases. For a review of the literature regarding vital pulp therapy in immature permanent teeth, the following research question was formulated: What are the various treatment options for preserving the vitality of the pulp in immature permanent teeth?

Databases including Ovid MEDLINE, EMBASE, and EBM Reviews were searched for literature in addition to textbooks and journals. Articles were selected by reviewing the titles and abstracts. Full-text papers were obtained where there was insufficient information to assess inclusion from the title and abstract. The articles identified were hand-searched and bibliographies from the relevant articles were searched where necessary. 248 articles were identified. After removing duplicate results and articles that did not meet the inclusion criteria a total of 26 articles were finalized.

RESULTS AND DISCUSSION

According to the MeSH (Medical Subject Headings) browser, pulp capping is defined as, “Application of a protective agent to an exposed pulp (direct capping) or to the remaining thin layer of dentin over a nearly exposed pulp (indirect capping) in order to allow the pulp to recover and maintain its normal vitality and function.”

Indirect pulp capping: Various treatment strategies have been used to treat deep carious lesions which would prevent pulpal damage. Indirect pulp capping is a procedure that involves the removal of carious dentin until a thin layer of nearly exposed pulp remains.

This procedure has been described by researchers as either a one or two-visit procedure, whereas others describe the 1 visit procedure as indirect pulp therapy and the two-visit procedure as ‘stepwise excavation.’[15] This review will refer to the latter terminologies.

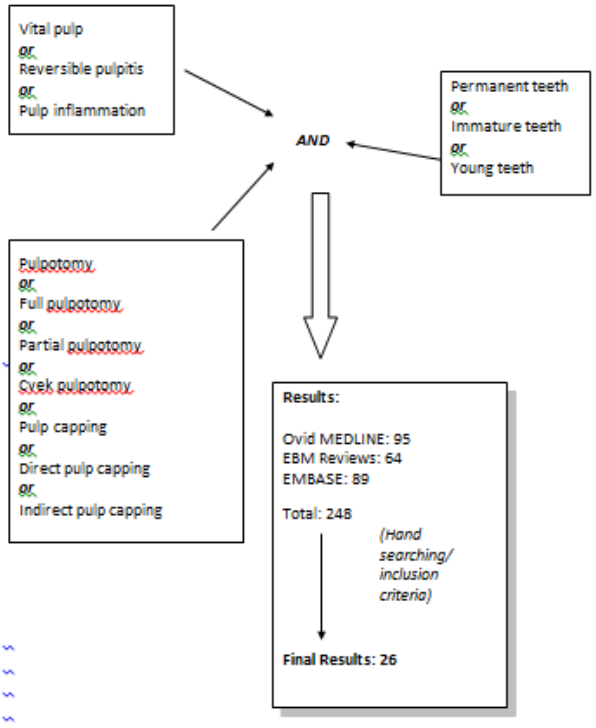

Figure No.1: Search strategy- Part One (Search terms and results)

Table No.1: Inclusion and Exclusion Criteria

	Inclusion Criteria	Exclusion Criteria
Participants	Patients with immature / young permanent teeth	- Deciduous teeth - Fully developed permanent teeth
Interventions	An interventions or combination of interventions involved in vital pulp therapy, including: - Indirect pulp capping. - Direct pulp capping. - Partial pulpotomy, Cvek pulpotomy. - Full coronal pulpotomy.	- Pulpectomy - Apexification - Regeneration - A comparison of the vast variety of pulp dressing materials.
Outcomes	Any clinical outcome related to	None

	maintained pulp health including: survival rate, success rate, pulp vitality, pulp exposure, clinical signs and symptoms, periapical radiographic appearance, continued root development.	
Study design	All relevant studies	None

These procedures are ideally performed in teeth with deep carious lesions, in the absence of clinical signs and symptoms of pulpal or periapical disease. The tooth should have a normal or reversibly inflamed pulp, with no evidence of macroscopic exposure of the pulp. However, recent evidence suggests that VPT procedures can be carried out in teeth with irreversible pulpitis.[8,16]

The concept of indirect pulp capping is based on the theory that as the outermost layer of 'infected' dentin is removed, getting rid of most of the bacteria, there is remineralization of the demineralized 'affected' dentin present between the layer of infected dentin and pulp leading to the formation of reparative dentin. The outer layer is composed of dead, infectious tissue whereas the inner layer has living tissue with sound structure and the capability to remineralize.[17] In the case of an affected pulp, the inflammation is reversible and the layer of reparative dentin is deposited below the affected dentin. However, it is difficult to determine whether the dentin is affected or infected.

This technique involves caries removal as close to the pulp as possible, leaving a thin layer behind to avoid exposure. A protective material that promotes healing and repair is placed on the floor of the cavity and the tooth is permanently restored without subsequent re-entry.[17,18] This approach's risks may include pulpal exposure during deep caries excavation or the possible development of irreversible pulpitis.[19] In order to reduce these risks, the stepwise excavation technique has been proposed. The difference between these two procedures is subsequent re-entry into the tooth.

The stepwise excavation approach involves two stages. The first step involves removing the outermost portion of infected carious dentin leaving residual carious dentin close to the pulp-dentin interface. A protective material is then placed over the residual carious dentin followed by a well-sealed temporary restoration. The second step involves re-entry and removal of remaining caries followed by the placement of a final restoration. The objective of this two-stage procedure is to reduce the risk of pulpal exposure, reduce the number of bacteria and change the cariogenic environment resulting in slowing or arresting of the carious process.[20] There is controversy regarding the need for re-entry into the tooth after the first stage of caries removal. The biological rationale for not re-entering and leaving a thin layer of caries remaining in the cavity has already been described in indirect pulp capping.

However, some maintain that re-entry into the tooth is significant for two main reasons. Firstly, if the restoration fails, and micro-leakage occurs, the carious lesion would reactivate and already be in an advanced stage.[21] Secondly, during the interval between the first and the second stage of treatment, the carious lesion becomes harder, darker, and dry.[22] There is a reduction in the size of the lesion which results in shrinkage and a gap between the tooth and restoration.[23]

Previously indirect pulp therapy was a treatment modality that was frowned upon. Professor Nygard Ostby has been quoted as stating in his lectures: "To intentionally and permanently leave caries is malpractice and this kind of procedure should be pronounced indirect pulp capping".[24] More recently, however, with an increased understanding of the carious process, conservative caries removal has gained some support. There is much controversy regarding the best treatment option for managing deep caries. This is discussed further below.

Direct Pulp capping: Direct pulp capping is a method that includes covering the pulpal tissue with a protective dressing or base placed directly over the exposed pulp tissue. This technique is usually indicated in a tooth with a normal pulp, no symptoms, and a mechanical, non-carious exposure, in which a well-sealed coronal restoration can be placed.[25]

After adequate anesthesia and isolation, the tooth can be rinsed with chlorhexidine or sterile saline solution. If bleeding occurs this should be controlled as previously described. A protective material, such as calcium hydroxide or mineral trioxide aggregate (MTA), is placed over the exposure site.[26]

The literature on the treatment outcome of direct pulp capping is conflicting. The conventional consensus is that this procedure has an unpredictable and poor outcome when performed in teeth with carious exposures of the pulp. [27] This is because the pulp has come into direct contact with microorganisms and is inflamed.

However, a relatively new approach has been advocated by some researchers. This involves the complete excavation of caries followed by pulp capping of the resultant exposure. The procedure is similar to the one described above. MTA has been used as the pulp dressing material. This procedure was performed in 30 asymptomatic young, permanent molars. At 24 months, around 93% were still vital and showed continued root development.[28] Another study performed this procedure in 15 immature permanent teeth with deep caries and

reversible pulpitis. After an average follow-up of 3.94 years, all teeth showed continued root development.[29]

A retrospective study looking at the outcome of pulp capping in cariously exposed teeth after five and ten years showed a failure rate of around 44.5 % and 80% respectively.[30] However, this study included a follow-up of only around 31% of the teeth treated. Also, the extent and nature of the bleeding was not reported.

Some studies showed higher success rates, such as 97.8% and 79%.[31] However, these studies had shorter follow-up periods, of 1.5 and 1 year, respectively. Long-term studies show that the likelihood of teeth becoming non-vital within five years after treatment is high.[32] The available evidence indicates that the success of direct pulp capping reduces over time and further long-term studies are required.

Pulpotomy: Pulpotomy is described as a procedure whereby exposed pulpal tissue is removed so that the vital function of the remaining tooth may be preserved. If the superficial part of the pulp is removed this is known as partial pulpotomy, whereas, a procedure in which the entire coronal pulp is removed is known as a full pulpotomy or coronal pulpotomy.[33]

Partial pulpotomy or Cvek pulpotomy is described as a method including removal of superficial inflamed pulpal tissue to the level of healthy coronal pulp. The rationale for partial pulpotomy is that once the exposed, inflamed or damaged pulp tissue is removed, the remaining tissue will remain healthy and vital and a hard tissue barrier will seal the exposure site.[34] Full pulpotomy is a procedure in which the entire coronal pulp is removed, usually to the level of the root canal orifices or 2-3 mm apical to the orifices.[35]

Indications and prognosis

Partial pulpotomy: This procedure may be carried out in teeth with traumatic or carious exposures only if pulpal bleeding can be controlled and the tooth has a normal or reversibly inflamed pulp. Partial pulpotomy in cariously exposed, young, permanent teeth has shown a success rate of over 90%.[36]

Full pulpotomy: This procedure is indicated in cases where the coronal pulp is severely damaged but the radicular pulp is still vital. It is indicated in cases where inflammation of the coronal pulp to deeper levels is anticipated, such as in carious exposures or traumatic exposures older than 72 hours.[37]

Pulpotomy in symptomatic young permanent teeth:

Some success of pulpotomy in symptomatic teeth has been reported. In a study, a full pulpotomy carried out in twenty teeth with deep caries was reported to have clinical success at six months and one-year time. On radiographs, continuous radical development was observed in the immature roots with dentinal bridge formation detected in 10% of the teeth.

In teeth showing periapical rarefaction, healing signs were observed. One tooth showed signs of internal root resorption at one year having a success rate of 95%.[38]

Technique for full coronal pulpotomy and partial pulpotomy (Cvek pulpotomy):

These procedures are similar to direct pulp capping except removing tooth tissue. The pulp is amputated until the level of tissue damage is. This removes the part of the pulp that may be affected by inflammatory changes or bacterial infiltration so that the wound is situated in healthier tissue.[39]

The assumed level of tissue damage is determined clinically as the level at which bleeding can be easily controlled. Inflammation resulting from traumatic injuries usually extends a few millimeters into the pulp. In partial pulpotomy, around 2mm of the exposed pulp is removed. In full coronal pulpotomy, the pulp tissue is usually removed up to the root canal orifices. Bleeding is controlled and the pulp wound is dressed with pulp capping.[40]

CONCLUSION

Implications for clinical practice: A review of the literature advocates the use of pulp capping and pulpotomy treatment modalities in immature, permanent teeth. Generally, it seems that pulpotomy may give more predictable outcomes for carious exposures or larger and older traumatic exposures than direct pulp capping. This is because of the possible removal of inflamed/damaged tissue.

Vital pulp therapy has shown more predictable outcomes in teeth with normal pulps (asymptomatic) or those with reversible pulpal inflammation. Few studies show success in irreversibly inflamed pulps.

The success of treatment may decrease over time, therefore, a long follow-up of at least five years is recommended.

Implications for research: Currently, there is limited evidence to allow firm conclusions to be drawn about indications in symptomatic teeth. Further high-evidence-level studies are required to assess the long-term treatment outcomes and factors affecting success. Research should also be conducted to determine accurate, reliable, and practical methods for diagnosing the state of the pulp.

Although a detailed analysis of pulp dressing materials was beyond the scope of this review, the vast variety of pulp dressing materials and their potential impact on pulpal healing merits further study.

Author's Contribution:

Concept & Design of Study:	Yasir Alyahya
Drafting:	Yasir Alyahya
Data Analysis:	Yasir Alyahya
Revisiting Critically:	Yasir Alyahya
Final Approval of version:	Yasir Alyahya

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