

## Conservative Management of Endodontic Exposure

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Received: June 22, 2021; Published: June 29, 2021

### Abstract

**Introduction:** Healthy pulp tissue is of utmost importance so as to prevent the inflammation throughout the pulp causing various periapical pathosis therefore, the maintenance of the same forms the basis of minimally invasive dentistry. Although, the dental pulp itself exhibits various protective mechanisms against irritation, yet the conservative management of the exposed pulp has been unpredictable. Vital pulp therapy (VPT) is a commonly done procedure in deciduous dentition for maintenance of pulp and preservation of tooth. The same has been advocated in mature permanent teeth as well as a conservative method for mechanical, iatrogenic, and carious pulpal exposure. The earlier studies showed the poor outcome of VPT but the advent of more advanced dental biomaterial and evolving understanding of molecular biology and regenerative medicine have led to the era of new treatment strategies for the exposed pulp. Knowledge of histopathology and bacteriology of the cariously exposed pulp is also a key factor for proceeding to this ultraconservative management of pulp exposure. The healing potential of the inflamed pulp, proper case selection, appropriate restorative and capping material selection, strict aseptic condition, good marginal seal are some crucial factors for the long-term success of these treatments.

**Aim of the Study:** The purpose of this review is to understand and have a different perspective of vital pulp therapy and its better role in the preservation of pulpal inflammation and disease in pulpal exposure along with the various advanced capping material used for the same.

**Methodology:** The review is a comprehensive research of PUBMED, MEDLINE, SCOPUS, SCHOLAR from year 1963 to 2020.

**Conclusion:** Maintenance of pulp vitality by the adoption of minimally invasive procedures is highly encouraged in adult teeth with carious pulp exposure. Parallel with the need for an update of the diagnostic terminology of the state of the pulp, there is an urgent need for a more representative pulpal diagnostic method.

**Keywords:** Vital Pulp Therapy; Calcium Hydroxide; Calcium-Silicate-Based Biomaterials; Pulp Exposure

### Introduction

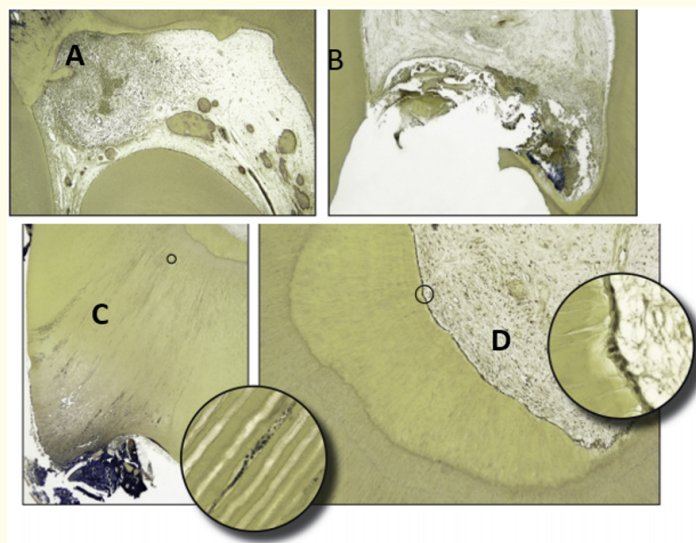
Endodontic exposure due to carious exposure, mechanical trauma, or iatrogenic causes can compromise the pulp integrity and leads to various sequelae of pulpal diseases if not met with early intervention. Iatrogenic injuries are not insignificant pulpal injury which may

include short term pulpal inflammatory lesion and hypersensitive tooth, frequently associated with removal of dental hard tissue structure in very close proximity to pulp [1].

Dental caries is also a highly prevalent disease and inflammation of pulpal tissues of a carious process occurs way before actual pulpal exposure in carious teeth. But despite pulpal exposure, the inflammation in pulp is confined within 2 mm of pulp exposure unless it is a long-standing carious lesion. Considering this root canal therapy is not justifiable in such cases where the remaining healthy coronal and radicular pulp beneath inflamed pulp can be treated with a more conservative treatment approach such as vital pulp therapy which includes indirect pulp capping, direct pulp capping, partial and full pulpotomy [2,3].

**The dilemma of vital pulp therapy in exposed pulp and histopathological correlation**

VPT in the management of deep lesions and pulp exposure has always been a dilemma among clinicians. whether the dental pulp should be preserved to maintain vitality or completely removed to prevent necrosis, the infection has always been a controversial topic of debate among authors. Because of the unreliability of the VPT procedure and lower success rate of 13 - 37% in 10- year follow-up cases, it is not favored by the majority of dentists until recently. There is another perspective emerging which favors the success rate of VPT in mechanical or traumatic exposure [4]. The American Association of Endodontists (AAE) Glossary of Endodontic Terms [5] recommends the use of direct pulp capping only when pulp exposure is produced mechanically (i.e. accidentally) or traumatically. Contrary to this deep-rooted professional dictum, studies published before the 2000s [6] and more recent studies have reported successful outcomes VPT (pulpotomy) when performed in cariously exposed pulps of permanent vital teeth that were presented with the signs and symptoms of irreversible pulpitis and even apical periodontitis [7].



**Figure 1:** (A) Overview of the carious lesion showing bacteria within the dentinal tubules of the circumpulpal secondary dentine (B) High magnification of the tubular tertiary dentine and the subjacent pulp. Bacteria were absent in the tertiary dentine; Different extents of partial necrosis in the pulp chamber, (C) showing Mandibular second molar, the mesial half of the pulp was necrotic, (D) Maxillary second premolar. the superficial portion of the pulp was necrotic, separated from the underlying vital pulp tissue by a clear demarcation line [8].

From a histological point of view, the clinical management of exposed pulp/pulpitis should be based on the prognosis of treatment. If the pulp is reversibly inflamed and there are no signs of infection, inflammation, necrosis, or presence of micro-abscesses or foci of infection throughout the pulp except for the superficial exposed area then pulp can be preserved entirely by conservative procedure by VPT. On the contrary, if the signs of inflammation are present partially or throughout the pulp, directly capping it will exhibit poor prognosis. The pulpal degeneration on the basis of clinical signs and symptoms can never be demonstrated therefore establishing a treatment plan based on clinical signs and symptoms remain questionable. According to histopathological and histobacteriological findings, it can be concluded that there is a thin line between the terms “reversible” and “irreversible” pulpitis and is referred to the conditions of part and not the entire pulp tissue [8].

**Overview of treatment option of exposed pulp [9]**

Treatment		Indication and Technique
Direct Pulp Capping	Class I	<ul style="list-style-type: none"> <li>Not a carious lesion. Pulp exposure judged to be through sound dentin with an expectation that the underlying pulp tissue is healthy.</li> <li>Traumatic exposure.</li> </ul>
	Class II	<ul style="list-style-type: none"> <li>Deep or extremely deep carious lesion. Pulp exposure through a zone of bacterial contamination with an expectation that the underlying pulp tissue is inflamed.</li> <li>Symptomatic tooth indicating reversible pulpitis.</li> <li>The enhanced operative protocol employed (aseptic procedure, magnification, disinfectant, and a hydraulic calcium silicate cement).</li> </ul>
Pulpotomy	Partial	<ul style="list-style-type: none"> <li>Pulp exposure following trauma or caries.</li> <li>Symptomatic tooth indicating reversible pulpitis.</li> </ul>
	Full or Complete	<ul style="list-style-type: none"> <li>Pulp exposure following caries removal.</li> <li>Symptomatic tooth indicating reversible pulpitis evolving to irreversible pulpitis.</li> <li>Partially irreversible pulpitis confined to coronal tissue.</li> </ul>

**Procedure and case selection**

The pulp is a soft connective tissue encased in hard dental tooth structure and is protected by an outer layer of enamel and dentin, which can be breached by trauma, caries, or iatrogenic reasons making pulp exposure and pulp vulnerable to microbial colonization. This invokes a pulpal inflammatory response which itself is a reparative phenomenon but at times when remains untreated and can potentially cause pulpal necrosis. In order to prevent any further progression of this, the irritant stimulus should be removed, the exposed pulp should be capped with appropriate capping material and restoration should be provided. This procedure forms the basis of vital pulp therapy [9].

Some important aspects of conservative pulp exposure are as follow:

1. Assessment of the inflammatory status of pulp (whether reversible or irreversible).
2. Aseptic management of remaining dental-pulp tissue in each and every step is most crucial for vital pulp therapy and its long-term prognosis.
3. Choosing an appropriate capping material.

4. Permanent restoration.
5. Follow up and further assessment of the inflammatory status of pulp and periapical status [9].

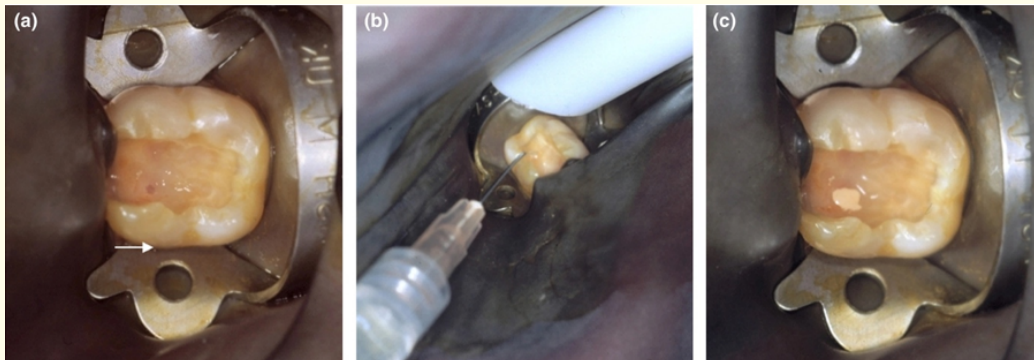
### Case selection

1. **Age:** Most of the studies in VPT favor the procedure in the younger age group but with the advancement of material such as Mineral Trioxide Aggregates (MTA), age does not appear to be a significant factor in case selection at present time [10].
2. **Pulp sensibility testing:** Cold testing is the most valid test for identifying necrotic pulps and therefore it is essential to perform a cold test before starting VPT in deep carious lesions or lesions exposing the pulps [11].
3. **Radiographic assessment:** Intraoral periapical radiograph may be essential for assessment of depth of caries as well as periapical status. It has been stated in various studies that the presence of a periapical lesion of an inflamed vital pulp is not a contraindication for VPT, and various studies reported successful outcomes of pulpotomy in such cases [12].
4. **Visual assessment:** A direct observation of the pulp exposure/wound under magnification is recommended; ideally a healthy pulp wound includes a continuous blood-filled tissue surrounded by clean sound dentin. If there is necrotic tissue, dentin debris, or yellow areas within the pulp, then it is advisable to remove more tissue in partial pulpotomy and reassessed again for the need of full pulpotomy. Another method for assessment of inflammation is the severity of bleeding after pulp exposure; profuse bleeding indicates severe inflammation, need further removal of pulp tissue until uninflamed tissue is encountered, and achieve hemostasis [10].
5. **Microbial control:** All the operative procedures and caries excavation should be done under strict rubber dam isolation, though microbial control is not under control in case of traumatic pulpal exposure. The exposed pulp cavity should be disinfected with a disinfectant such as 1% NaOCl or chlorhexidine to minimize bacterial load and prevent embedment of dentin debris into the pulp tissue, which potentially interferes with subsequent healing pulpal tissue. In pulpotomy procedure, hemostasis is often achieved by using low concentrations of NaOCl (1% - 3%) on a cotton pellet [13].
6. **Hemostasis as an indicator of pulpal inflammation:** The association between the bleeding time and the degree of pulp inflammation has not been thoroughly investigated but according to studies, high success rates were reported with bleeding time between 1 and 10 minutes. The degree of bleeding on pulp exposure is not a sufficient parameter for the prognosis of VPT, but persistent bleeding despite various attempts at achieving hemostasis is considered a contraindication to VPT, and pulpectomy is a recommended procedure in such cases [12,14].

### Direct pulp capping

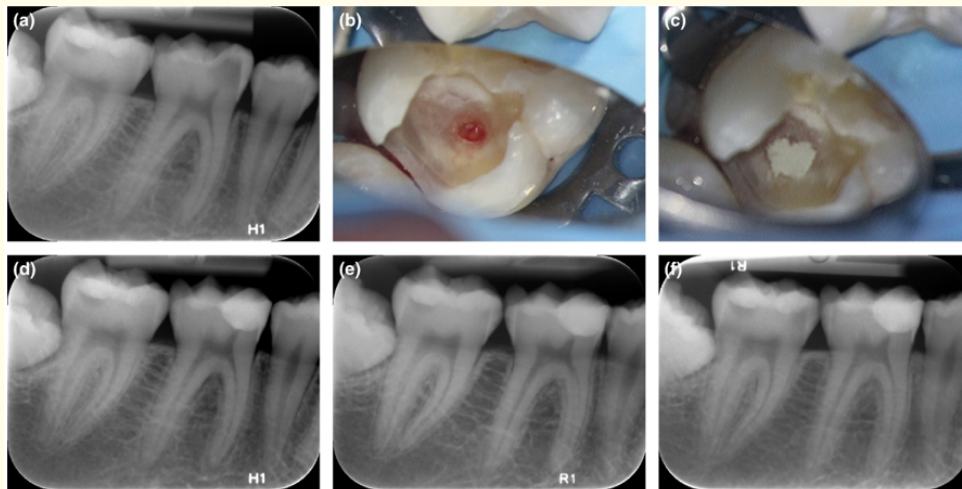
Direct pulp capping can be divided into class I and II exposures.

Class I is commonly performed in cases of small traumatic or iatrogenic pulp exposures when the exposure is deemed to be through healthy dentine and the pulp is normal. It includes arresting any pulpal hemorrhage followed by covering and sealing exposed pulp tissue in order to preserve its health, function, and viability. Sealing of the pulp exposure is done using an appropriate capping agent and restoring the remainder of the tooth with a permanent restorative material. Other factors which are important prior to undergoing class I pulp capping are that the exposure must be small (preferably < 1 mm diameter), located in the coronal third of the pulp chamber, corresponding to a pulp horn [9,15].



**Figure 2:** Showing (A) Small pin-point exposure, (B), (C) calcium hydroxide placement [15].

Class II pulp cap is indicated after the exposure of asymptomatic or reversibly inflamed pulp tissue during carious tissue excavation. An enhanced treatment protocol is needed for this so as the prefix class II suggest, it indicated an altered treatment that requires fixing microbial challenge which is otherwise almost nil in class I direct pulp capping. This includes carious removal guided by the use of the operating microscope, hemostasis attained within 5 min, followed by use of 5.25% NaOCl and restoration with a hydraulic calcium silicate cement [9,15,16].



**Figure 3:** Showing (a) Preoperative with deep lesion and no periapical pathosis. (b) Nonselective carious removal using the operative microscope, absence of any retained carious dentine is noted along with good hemostasis of the exposed pulp. (c) Placement of the mineral trioxide aggregate capping agent. (d) Post-operative radiograph with the permanent restoration in place. (e) One-year follow-up and (f) two-year follow-up radiograph [15].

### Pulpotomy

Pulpotomy is a vital pulp treatment procedure that includes the removal of varying degrees of pulp tissue in order to further prevent the progression of pulpal inflammation and thereby maintaining the integrity of the remaining healthy pulp. Partial or complete coronal pulpotomy is indicated in pulp exposures due to caries. The advantage of partial pulpotomy over direct pulp capping is that it provides space for the dressing material which seals the cavity entirely providing a good marginal seal [9,17].

Partial pulpotomy is a procedure removal of coronal pulpal tissue up to the depth of 3 mm or complete/full pulpotomy up to the root canal orifices is commonly practiced in teeth with signs and symptoms which is indicative of the evolution of reversible partial irreversible pulpitis of the coronal tissue [9,17].

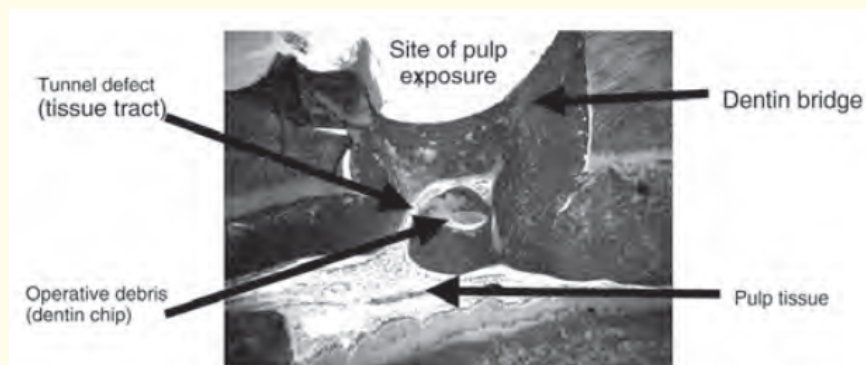
The steps of pulpotomy are as follows:

- A non-selective removal of all carious tissue is done until hard dentin is reached (i.e. complete removal of the lesion).
- The portion of the coronal pulp tissue is removed using a sharp hand excavator or a high-speed drill with a generous water coolant.
- After exposure to the pulpal wound, the debris of the pulp tissue is cleansed using a 2-5% of sodium hypochlorite solution.
- Pulpal bleeding is arrested by applying pressure for as long as the bleeding stops, using cotton wool pellets soaked in sodium hypochlorite solution.
- After pulpal bleeding is arrested, a calcium-silicate-based pulp capping material is used as a pulp capping agent.
- Thereafter, an appropriate permanent restoration is placed according to the requirement [9,17].

### Pulp capping material

#### Calcium hydroxide

Calcium hydroxide is one time tested material used as pulp capping for many decades. Despite long-term studies on calcium hydroxide, the outcome associated with it varies to a large extent. It is highly alkaline in nature with pH-11, which owes to its antimicrobial property, causing irritation to the pulp which in turn evokes pulpal defenses and repair. The ability of calcium hydroxide extract growth factors and bioactive dentin matrix components from mineralized dentin can induce dentin regeneration at the site of pulpal exposure however, the material is also known to be toxic to cells and the dentin bridge formed by calcium hydroxide showed porosity and tunnel defects as the material resorbs over a period of time [17-19].



**Figure 4:** Showing the “tunnel defect” associated with calcium hydroxide as pulp capping agent [19].

### Mineral trioxide aggregates (MTA)

MTA started its journey as root-end filling material to root perforation and is now widely used as a pulp capping agent in vital pulp therapy because of its favorable biologic responses. MTA works by provoking recruitment and proliferation of undifferentiated cells and differentiate them into odontoblast-like cells. The dental pulp cells have more activation when in contact with MTA and were faster, more predictable in dentin bridge formation, also and more effective in terms of pulpal repair. Hence this material gained more popularity than calcium hydroxide in recent years. It forms a thicker dentin bridge and less inflammatory response as compared to calcium hydroxide. The use of MTA in pulpotomy of permanent teeth showed no pain post-procedure. But despite all these advantages, MTA has drawbacks of difficult handling properties, long setting time, tooth discoloration, and high cost [17,20,21].

### Bioceramics

Many bioceramic materials have been introduced in the market which can be used as pulp capping agents. Bioceramic material shows almost similar efficacy to MTA and the same cytotoxicity. Eg. EndoSequence Root Repair Material (ERRM, Brassler, Savannah, GA, USA), BioAggregate (Verio DentalCo, Vancouver, Canada), Biodentin (Septodont, Saint-Maur-des-Fosses, France) [22].

### Calcium enriched mixture (CEM)

CEM was introduced as root-end filling material. The powder components of cement are calcium oxide (CaO), sulfur trioxide (SO<sub>3</sub>), phosphorous pentoxide (P<sub>2</sub>O<sub>5</sub>), and silicon dioxide (SiO<sub>2</sub>). The flow, film thickness, and primary setting time of this material are favorable and its clinical applications are similar to MTA. CEM when compared with other agents exhibited lower inflammation, improved quality/ thickness of calcified bridge, superior pulp vitality status, and morphology of odontoblast cells. However, no significant differences were identified in comparison to MTA. CEM showed a better success rate in pulpotomy procedures of symptomatic permanent [23].

### Other bioactive materials for VPT

Enamel Matrix Derivative (EMD) and Propolis are some other materials that have been also used as a pulp capping agent. The major constituent of EMD is amelogenin, a protein that is secreted during odontogenesis from pre-ameloblasts, differentiating odontoblasts in the dental papilla. The comparative study of calcium hydroxide and EMD regarding inflammation and dentinal bridge formation is mixed. EMD also showed good results when used along with other capping agents by increasing its biocompatibility [24].



**Figure 5A-5C:** Showing histopathological section (hematoxylin-eosin stain; magnification 10×): (A) MTA (B) Biodentine; (C) Propolis. {D, dentin; DB, dentin bridge; MTA, mineral trioxide aggregate} [26].

Propolis is a natural product showing potent antimicrobial and anti-inflammatory properties. It inhibits prostaglandin synthesis, helps the immune system by promoting phagocytic activities, stimulates cellular immunity, and augments healing effects. It also contains elements like zinc and iron that are essential for collagen synthesis. In comparison with other materials, propolis showed a higher quality of tubular dentin formation. According to a study on the quality and quantity of dentin bridge formation of MTA, Biodentine was superior to Propolis but owing to its anti-inflammatory, antimicrobial, and tissue regeneration properties, it improves wound healing better [25,26].

### Conclusion

Maintaining the vitality of pulp in exposed pulp with a more conservative treatment approach can be very challenging. The better outcome of conservative treatment options like vital pulp therapy in the exposed pulp of permanent teeth, due to the emergence of various advanced pulp capping material is favoring such procedures over invasive procedure like pulpectomy. Despite successful outcomes in recent years it is to be noted that the histopathological status of pulp after exposure is one essential factor since the histopathological examination is not always feasible therefore the clinician must assess the conditions of the pulp tissue on pulpal exposure by direct examination, have a thorough knowledge for appropriate case selection and capping material used for such conservative procedure so that a more predictable treatment may be provided.

### Bibliography

1. Bergenholtz G. "Iatrogenic injury to the pulp in dental procedures: aspects of pathogenesis, management and preventive measures". *International Dental Journal* 41.2 (1991): 99-110.
2. Taha N A., et al. "Conservative management of mature permanent teeth with carious pulp exposure". *Journal of Endodontics* 46.9 (2020): S33-S41.
3. Seltzer S., et al. "The dynamics of pulp inflammation: correlations between diagnostic data and actual histologic findings in the pulp". *Oral Surgery, Oral Medicine, Oral Pathology* 16.7 (1963): 846-871.
4. Swift Jr E J., et al. "Vital pulp therapy for the mature tooth—can it work?" *Endodontic Topics* 5.1 (2003): 49-56.
5. American Association of Endodontists (AAE) Glossary of Endodontic Terms, ninth edition (2015).
6. Zilberman U., et al. "Partial pulpotomy in carious permanent molars". *American Journal of Dentistry* 2.4 (4): 147-150.
7. Aguilar P and Linsuwanont P. "Vital pulp therapy in vital permanent teeth with cariously exposed pulp: a systematic review". *Journal of Endodontics* 37.5 (2011): 581-587.
8. Ricucci D., et al. "Vital pulp therapy: histopathology and histobacteriology-based guidelines to treat teeth with deep caries and pulp exposure". *Journal of Dentistry* 86 (2019): 41-52.
9. Duncan H F and Yamauchi Y. "Pulp exposure management". *Clinical Dentistry Reviewed* 3.1 (2019): 1-9.
10. Matsuo T., et al. "A clinical study of direct pulp capping applied to carious-exposed pulps". *Journal of Endodontics* 22.10 (1996): 551-556.
11. Pigg M., et al. "Validity of preoperative clinical findings to identify dental pulp status: a National Dental Practice-Based Research Network Study". *Journal of Endodontics* 42.6 (2016): 935-942.
12. Taha N A and Abdelkhalder S Z. "Outcome of full pulpotomy using Biodentine in adult patients with symptoms indicative of irreversible pulpitis". *International Endodontic Journal* 51.8 (2018): 819-828.



13. Asgary S, *et al.* "Treatment outcomes of 4 vital pulp therapies in mature molars". *Journal of Endodontics* 44.4 (2018): 529-535.
14. Linsuwanont P, *et al.* "Treatment outcomes of mineral trioxide aggregate pulpotomy in vital permanent teeth with carious pulp exposure: the retrospective study". *Journal of Endodontics* 43.2 (2017): 225-230.
15. Bjørndal L, *et al.* "Management of deep caries and the exposed pulp". *International Endodontic Journal* 52.7 (2019): 949-973.
16. Bogen G, *et al.* "Direct pulp capping with mineral trioxide aggregate: an observational study". *The Journal of the American Dental Association* 139.3 (2008): 305-315.
17. Ghoddusi J, *et al.* "New approaches in vital pulp therapy in permanent teeth". *Iranian Endodontic Journal* 9.1 (2014): 15.
18. Barthel C R, *et al.* "Pulp capping of carious exposures: treatment outcome after 5 and 10 years: a retrospective study". *Journal of Endodontics* 26.9 (2000): 525-528.
19. Murray P E and Garcia-Godoy F. "The incidence of pulp healing defects with direct capping materials". *American Journal of Dentistry* 19.3 (2006): 171.
20. Paranjpe A, *et al.* "Direct contact with mineral trioxide aggregate activates and differentiates human dental pulp cells". *Journal of Endodontics* 37.12 (2011): 1691-1695.
21. Witherspoon D E, *et al.* "Mineral trioxide aggregate pulpotomies: a case series outcomes assessment". *The Journal of the American Dental Association* 137.5 (2006): 610-618.
22. Hirschman W R, *et al.* "Cytotoxicity comparison of three current direct pulp-capping agents with a new bioceramic root repair putty". *Journal of Endodontics* 38.3 (2012): 385-388.
23. Bidar M, *et al.* "Effect of calcium hydroxide premedication on the marginal adaptation of calcium-enriched mixture cement apical plug". *Dental Research Journal* 9.6 (2012): 706.
24. Nakamura Y, *et al.* "Enamel matrix derivative promotes reparative processes in the dental pulp". *Advances in Dental Research* 15.1 (2001): 105-107.
25. Burdock GA. "Review of the biological properties and toxicity of bee propolis (propolis)". *Food and Chemical Toxicology* 36.4 (1998): 347-363.
26. Mohanty S and Ramesh S. "Comparing Quality and Quantity of Dentin Bridge Formed Using Mineral Trioxide Aggregate, Biodentine, and Propolis: A Double-blinded Randomized Controlled Clinical Trial". *World* 11.5 (2020): 374.

**Volume 20 Issue 7 July 2021**

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