Review Article

Traditional Versus Advanced Pulp Capping Materials in Primary Teeth

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Abstract

In situations where pulp degeneration and carious lesions may coexist, pulp therapy is a regularly employed method. Mineral trioxide aggregate, a material that is now utilized for indirect pulp treatment (IPT), is nontoxic and nonmutagenic. There is proof that the restoration margin can be sealed to manage the caries lesion. In terms of the clinical and radiological outcome, it has been demonstrated that IPT is more effective and secure than direct pulp capping and pulpotomy. The pulp capping treatment's goal is to protect the pulp from microorganisms as well as from thermal, electrical, chemical, and physical stimulation. There is evidence that suggests targeted caries clearance and composite restoration may stop caries lesions more effectively than full dentin removal. Various pulp capping materials that are available in the market were highlighted in this review, and the discussion of each material was expanded to demonstrate its clinical efficacy. Articles were specifically selected and discussed for the materials used for the IPT in the primary teeth as very few studies have been done so far in relation to this subject. A literature search in various libraries, including PubMed, Cochrane, ResearchGate, Scopus, ScienceDirect, and other libraries, was done for several available materials that have been used for the IPT procedure in primary dentition in the last 20 years.

Keywords: Calcium hydroxide, glass-ionomer cements, indirect pulp treatment, mineral trioxide aggregate, pulp capping, zinc oxide/eugenol

Résumé

Dans les situations où une dégénérescence pulpaire et des lésions carieuses peuvent coexister, la thérapie pulpaire est une méthode régulièrement employée. Agrégat de trioxyde minéral, un matériau qui est maintenant utilisé pour le traitement indirect de la pulpe (IPT), est non toxique et non mutagène. Il est prouvé que la marge de restauration peutêtre scellé pour gérer la lésion carieuse. En termes de résultats cliniques et radiologiques, il a été démontré que le TPI est plus efficace et plus sûr que le coiffage pulpaire direct et la pulpotomie. Le but du traitement de coiffage pulpaire est de protéger la pulpe des micro-organismes ainsi que des stimulation thermique, électrique, chimique et physique. Il existe des preuves suggérant que l'élimination ciblée des caries et la restauration composite peuventarrêter les lésions carieuses plus efficacement que l'ablation complète de la dentine. Divers matériaux de bouchage pulpaire disponibles sur le marché ont été mis en avantdans cette revue, et la discussion de chaque matériau a été élargie pour démontrer son efficacité clinique. Les articles ont été spécifiquement sélectionnés etdiscuté pour les matériaux utilisés pour l'IPT dans les dents de lait, car très peu d'études ont été réalisées jusqu'à présent sur ce sujet. Littérature une recherche dans diverses bibliothèques, notamment PubMed, Cochrane, ResearchGate, Scopus, ScienceDirect et d'autres bibliothèques, a été effectuée pour plusieurs matériaux disponibles qui ont été utilisés pour la procédure IPT en dentition primaire au cours des 20 dernières années.

Mots-clés: Hydroxyde de calcium, ciments verre ionomère, traitement indirect de la pâte, agrégat de trioxyde minéral, coiffage de la pâte, oxyde de zinc/eugénol

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Introduction

Pulp treatment is a frequently used procedure in conditions like carious lesions which may occur along with pulp degeneration. Mineral trioxide aggregate (MTA) is a nontoxic and nonmutagenic substance that is presently used for indirect pulp capping (IPC) or indirect pulp treatment (IPT). It is a debatable discussion whether MTA is more efficient than calcium hydroxide (Ca OH2) to form dentine bridges. The cytotoxicity of MTA is found to be minimal and it can prevent bacterial growth as well.[1-3] There are some studies that have shown that IPT can be mixed with 2% chlorhexidine gluconate and resin-modified glass ionomer in permanent molar teeth which has led to effective outcome. The benefit of having inhibitory activity against cariogenic bacteria is of the many benefits of using glass-ionomer cements (GICs) or reinforced zinc oxide/eugenol (ZOE) restorative materials.[4-7] There is evidence which shows that the caries lesion can be managed by sealing the restoration margin. IPT has been shown to be efficient and safer compared to direct pulp capping and pulpotomy in terms of clinical and radiological outcome. For IPT, various materials were used, such as Ca OH2 liner, GIC, dentin agents, zinc oxide, and calcium silicate.[8-10] A novel substance called Biodentine, which resembles natural dentine, has now taken over as the preferred material since it promotes the production of Biodentine, is antimicrobial and biocompatible, and after just 30 days of use, its compression strength can reach up to 300 MPa.[11]

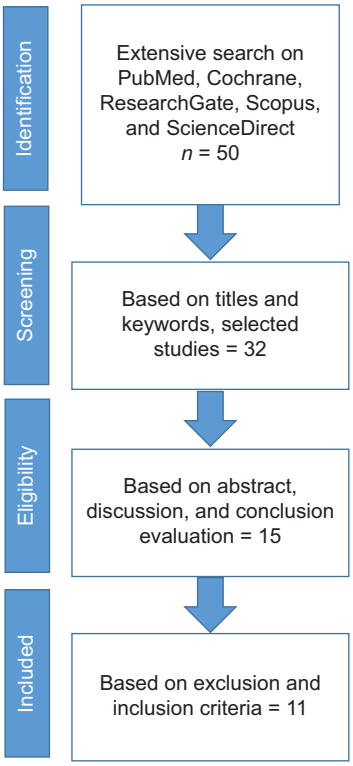

Figure 1: The preferred reporting items for systematic reviews and meta-analyses (PRISMA) diagram showing the selection of articles for this study

Methods and Search Strategy

The study has conducted a literature search in various libraries, including PubMed, Cochrane, ResearchGate, Scopus, ScienceDirect, and other libraries. The keywords used for searching were (Conventional OR Traditional) AND (Pulp OR Capping OR Capping Material) AND (Primary Teeth OR Primary Dentition) AND (Indirect pulp therapy OR Indirect pulp treatment). The publications that were included in this study are only systematic reviews and meta-analysis, clinical trials, or randomized control trials which have compared several available materials that are being used for the IPT procedure in the primary dentition in the last 20 years (from 2010 to 2022). The full copies of the included titles only in the English language were included, and those without full copies, along with literature review articles, case reports, and *in vitro* studies were excluded. The data were collected by two reviewers independently to minimize the risk of bias (detection bias, attrition bias, and reporting bias) in assessing the eligible studies. The search strategy has been schematically presented in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram [Figure 1]. Eleven studies were selected based on the above criteria, and a table giving the summary of the selected studies is documented as Table 1.

Discussion

The purpose of pulp capping treatment is to shield the pulp from microorganisms as well as physical, chemical, thermal, and electric stimulation. It seeks to maintain the pulp's vitality, block the dentinal tubules, and encourage the growth of pulp cells and odontoblasts into dentinal bridges. One or more coatings of pulp capping agent must be applied for the pulp capping treatment. When the remaining dentin thickness is >0.5 mm, base materials are used underneath the restorative material, while liners are suggested when the remaining dentin thickness is <0.5 mm. Since the pulp tissue and pulp capping agents come into touch frequently, they should be biocompatible and nontoxic. They have to be able to connect to restorative materials and dentin, offer an ideal seal, reduce microleakage, release fluoride, and do all of the aforementioned. Due to its outstanding antibacterial properties, ability to induce the production of dentinal bridges, low toxicity, and great clinical success rate, Ca OH2 has been utilized as a pulp capping agent for a very long time. Low compressive strength, however, is a significant disadvantage of CH. Thus, to offer sufficient compressive strength underneath the restorative materials, ZOE or GIC must be applied. With benefits like the capacity to release and absorb fluoride as well as adhering to enamel and dentin, GICs are also among the frequently utilized dental materials. Their disadvantages include low compressive strength and moisture sensitivity. The composition of GICs underwent some changes, leading to the advent of resin-modified GICs. Vitrebond is a resin-modified GIC that is marketed commercially and utilized as a liner for pulp capping. For application underneath ceramic, amalgam, metal, and composite restorations, all of the liners

Table 1: The studies that are evaluated in our review

Study	Procedure and findings	Conclusion
Casagrande *et al*.[12]	Did a randomized controlled trial and 5-year follow-up and tested materials for IPT. Sample size included 48 primary molar teeth. Adhesive resin system was used (Scotchbond Multi-Purpose) as the tested material, and Dycal was used as control	He stated teeth treated with adhesive technique (were successful by 93%) and teeth treated with calcium hydroxide (were successful by 80%). Adhesives or dentin bonding agents that were used for IPC did not form a calcific bridge and hence were not very successful as the ideal cement to be used for IPT
Gruythuysen *et al*.[13]	66 children (4–18 years) with a tooth with deep carious lesion were included. Incomplete excavation was done, and infected carious dentin was left. After the placement of a layer of resin-modified GIC as a liner, teeth were restored. A 3-year follow-up was done. Failure was defined as the presence of either pain or swelling. 86 out of the total treated 125 primary molars were available for evaluation	Survival rate was 96% for primary molars. This study proved that IPT done in the primary teeth of young patients resulted in a high survival rate
Rosenberg *et al*.[14]	This study analyzed IPT in 60 primary molars using 2% chlorhexidine gluconate solution as well as RMGIC liner after 12 months	Treatment was successful in 100%, 98%, and 97% teeth at 3-, 6-, and 12-month follow-up. Failures included were one at 6 months in a primary second molar with a composite restoration and one at 12 months in a primary first molar with a stainless steel crown
Trairatvorakul and Sastararuji (2014)[15]	Evaluated calcium hydroxide and compared it with 3Mix-MP and observed the teeth when IPT was done for 82 primary mandibular molars in 50 children, aged 3–8 years	Success rate of 82% for calcium hydroxide and 81% for 3Mix-MP was seen post 11 months as well as authors observed it to be 94% and 78%, post 29 months. 4 teeth (calcium hydroxide) as well as 1 (3Mix-MP) had failure when observed after radiographic examination. No difference in the success rate was seen in between both the cements at the time of both follow-ups
Petrou *et al*.[16]	Used MTA and calcium hydroxide for IPT in 48 of permanent and 38 primary teeth while doing 2-step IPT procedure. The tooth selected had deep carious. The treatment done included the incomplete caries removal and then randomly capping it with either calcium hydroxide or MTA, and then, it was followed by the reentry at 6 months. Clinical as well as microbiological evaluations were done	The authors recorded that IPT had a high success result of 90.3% for both materials being used
George *et al*.[17]	Examined dentin formation radiographically after doing IPT in 40 primary molars within the age group of 5–9 years and showed a significant difference in between both the MTA and Dycal at baseline as well as after 3 and 6 months	MTA was found to be better than Dycal when observed at follow-ups. Only one patient reported a problem of sinus at the interval of 6 months, but none of the teeth showed failure with the use of MTA. Hence, the final conclusion was drawn that MTA can easily replace Dycal for the IPT procedure
Mathur *et al*.[18]	Conducted IPT for 109 teeth in 94 children (7–12 years) with deep caries in either primary molar (50 teeth) or permanent molar. Teeth were treated by calcium hydroxide, glass ionomer, and MTA. Then, follow-up was done for 1 year. CBCT scan was done for examining dentin thickness	The results showed 100% success for the MTA, 93.5% for calcium hydroxide, as well as 97% success for GIC. The authors of the present study observed the success for IPC as 96.85%. Significant dentine barrier formation along with radiopacity was seen in all three groups at all three times of immediate and after 3 and 6 months. Hence, the conclusion was drawn that all three cements can be equally used for the IPT procedure
Menon *et al*.[19]	Did the study with the aim of evaluating both clinically and radiographically, the tertiary formation of dentin after doing the IPT procedure by applying MTA and comparing it with light curing TheraCal when used in 43 primary molars after analyzing it for a time interval of about 6 months. The researchers assessed tertiary dentin formation at baseline and after 3 and 6 months of doing a clinical trial of IPT in 43 primary molars in 21 patients aged 4–7 years using MTA as well as TheraCal	Both inter as well as intragroup comparisons were drawn, and it was finally concluded that there was an increase in the dentin thickness with both cements. Both cements had good handling properties as well as good tertiary dentin formation. Hence, it was concluded that TheraCal is a good alternative to MTA in pediatric restorative procedures
Garrocho-Rangel *et al*.[20]	Did the present study to assess both the clinical and radiographic outcome after applying a Biodentine as well as calcium hydroxide for the IPT procedure in 160 vital primary molars that had deep carious lesions approximating the pulp. Researchers did a follow-up of 12 months	120 teeth completed the follow-up period. The researchers compared both Biodentine and calcium hydroxide and observed success of 98.3% in Biodentine as well as 95% in the calcium hydroxide group. In the Biodentine-filled teeth group, only one tooth showed pain, while three teeth were counted as a failure and were observed in a 12-month follow-up period. However, no difference was observed in between the success rates of both the cements post 1 year follow-up period
Santos *et al*. (2017)[21]	Evaluated the success of IPT in primary teeth by analyzing them both radiographically and clinically. A thorough literature search was done up to 2017. After which the conclusions were drawn. 11 studies (full text) and 4 used for meta-analysis used calcium hydroxide as the control versus the placebo as resin-modified glass-ionomer cement and observed up to 48 months	The final conclusion was taken out that the cement used did not affect the IPT results. But still, calcium hydroxide proved to have more chances of failure. None of the scientific evidence proved any cement to be better than others when used in primary teeth

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Table 1: Contd...

Study	Procedure and findings	Conclusion
Gurcan and Seymen[22]	IPC was done in 295 teeth that included 135 second primary molars as well as 160 first permanent molars in 4–15-year-old children. Materials used were Dycal for 91 teeth, ProRoot MTA for 89 teeth, and TheraCal LC for 115 teeth. Primary molars were restored with the compomer material, and permanent molars were restored with the resin composite material. Restorations were evaluated at 24 months	No significant difference was observed between the materials. Success rates of ProRoot MTA, TheraCal LC, and Dycal were 94.4%, 87.8%, and 84.6%. Furthermore, no difference was seen in between primary and permanent teeth

IPT=Indirect pulp treatment, RMGIC=Resin-modified glass ionomer, MTA=Mineral trioxide aggregate, IPC=Indirect pulp capping

listed above should have sufficient compressive strength to withstand functional and parafunctional pressures in the oral environment.[3,23-26]

The American Academy of Pediatric Dentistry recommends indirect pulp therapy for teeth with severe carious lesions that do not exhibit any symptoms of pulp deterioration. This minimal intervention approach's primary objective is to alter the microenvironment of the infected dentin that has been purposefully left under the restoration. This will stop the cariogenic process and protect the tooth's structure and pulp health. In addition, because indirect pulp therapy has demonstrated greater radiographic and clinical success rates than pulpotomy, it is preferred to the latter. Primary teeth have had indirect pulp therapy using various materials, including Ca(OH)2 liners, dentin bonding agents, GIC, ZOE, calcium silicate, and medical Portland cement. Calcium hydroxide is the traditional and gold-standard material used for IPC; hence, it is used in comparison with the new advent of materials. Ca OH2 showed a similar success rate to cavity liners which eliminate the viable bacteria on the cavity floor and help in remineralization of the affected dentin; in addition to it, Ca OH2 shows various disadvantages as it disintegrates, and forms tunnel defects in the formed dentin. Due to microleakage, these patent tunnels are unable to create a hermetic seal to the underlying pulp against recurrent infection. After 6 months, it has been shown that the majority of Ca(OH)2 medications wash out and disintegrate, leaving a gap beneath the repair and an opening for bacterial infection. It even hydrolyzes over time which reduces the area for bonding which led to the use of various other materials such as adhesives, MTA, and GIC. The composites also undergo shrinkage and have less biocompatibility which affects the pulp. The study of indirect data reveals no distinction between resin-modified GIC and adhesive systems, while the latter showed a lower likelihood of pulp failure. The adhesives show similar results with Ca OH2 when restored with composite. In primary molars, it has been demonstrated that the survival rates of resin composite and resin-modified GIC restorations are comparable. In light of the benefits, including fluoride release, lesser postoperative sensitivity, and less technical difficulty, resin-modified GIC would be a desirable choice for indirect pulp therapy in primary teeth.[21,27-29]

MTA is used in the treatment of IPC. It is composed of dicalcium silicate, tricalcium silicate, calcium sulfate dehydrate, and tetracalcium aluminoferrite. The material's small size of the particle, sealing prowess, alkaline pH upon setting, ability to set in the presence of moisture, and gradual release of calcium ions gave the impression that it had been effective. MTA stimulates the growth of pulp cells, the release of cytokines, and the consequent development of hard tissue by causing the dentin to become mineralized in a manner akin to that of biological hydroxyapatite. Clinically, Ca OH2 and MTA are good, but based on the radiological findings, MTA is superior to Ca OH2 and dentin formation is faster in MTA. Apatite development and the production of reparative dentin have been observed to be stimulated by TheraCal LC, a new family of substances known as resin-modified calcium silicates. Both MTA and TheraCal LC have used the treatment of IPC due to their ability in forming reparative dentin. When compared to MTA, TheraCal LC has less solubility and releases a high amount of calcium. In the first 3 months, the reparative dentin formation is high with TheraCal LC.[17,19]

Evidence suggests that targeted caries clearance and composite restoration may produce superior clinical results than complete dentin removal for stopping caries lesions. Disinfection has been promoted as a more successful and conservative alternative to total caries eradication. A photo-activating liquid and a light-emitting diode (LED) light source are used in the method known as photo activated disinfection (PAD). The periodontal pathogens and cariogenic bacteria are the sole targets of the LED light source. Periodontology has used PAD as a tool for cleaning periodontal pockets. The findings showed that the temperature increase in the pulp was <3°C, which is thought to be safe for pulp injury. The use of PAD for periodontal pocket cleaning might be viewed as a safe method for dental vitality in terms of pulp temperature increase. The application of PAD in caries control can eliminate lingering germs in soft dentin, ensure quick healing, and enhance treatment outcomes. Young permanent teeth treated indirectly with Ca OH2 and PAD had equivalent radiographic and clinical success rates for treating deep carious lesions.[30-32]

Conclusion

The current review has discussed the capping materials available for pulp capping of primary and permanent teeth and also discussed 11 selected papers for effective comparison between the materials available for IPT specifically in the primary dentition. The review considered the findings and

conclusion of these studies and effectively discussed. The current review discussed several studies that dealt with various capping materials such as Dycal, ProRoot MTA, and TheraCal LC. The selected studies have been discussed and shown their respective conclusion to present a comparative discussion. The advantages and disadvantages of several materials have been discussed. This review brought forward the available capping materials for IPT for the primary teeth, and the discussion of each material has been elaborated to show the clinical efficacy. The only limitation is that still very few good clinical trials and research have been done in relation to primary teeth and more focus should be given on this particular aspect.

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Conflicts of interest

There are no conflicts of interest.

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