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Role of Indirect Pulp Capping In Pediatric Dentistry - A Review of the Literature

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Abstract
Pulp exposure of the dental pulp exists when the continuity of the dentin surrounding the pulp is broken by physical or bacterial means leading to direct communication between the pulp and the oral environment which will be managed by Indirect Pulp Therapy(IPT). IPT aims at treating deep carious lesions that are asymptomatic by removing the carious dentin that contain the majority of the microorganisms and sealing the lesion to allow pulp to regenerate tertiary dentin. The purpose of this article is to systemically review the IPT procedures, its materials and success rate by summarizing the review articles taken from Pubmed, Science direct, Scopus and other libraries.

Keywords: Indirect pulp capping , Indirect pulp therapy , pulp capping materials , Calcium Hydroxide , Zinc Oxide Eugenol , Glass Ionomer Cement

Introduction:

Dental caries are an unsolved problem all over the world[1]. Dental caries is an infectious microbiological disease resulting from tooth adherent cariogenic bacteria , primarily Streptococcus mutans, which metabolise sugars to produce acid, demineralizing the tooth structure over time[2]. Preservation of primary teeth is essential to prevent premature loss and possible unfavourable outcomes on function and development that include compromised occlusion and alignment, decrease in arch length, impaction, crowding, poor molar relationship, and ectopic eruption[2]. Management strategies for cariously exposed pulp are claiming the superiority of vital pulp treatment that involves Direct Pulp Capping (DPC), Indirect Pulp Capping (IPC) and pulpotomy [3]. IPC is performed in teeth where the caries lesion is deep and close to the pulp chamber, without any evidence of pulp exposure [4] . This therapy involves removing caries from the cavity walls and dentin-enamel junction while leaving caries in the cavity floor intact and covering it with a biocompatible material to create a biological seal that prevents essential exposure of pulp [5]. The objective of this procedure is to eliminate the cariogenic microbiota that alters the acidic profile and pH of the lesions, and to prevent the proteolytic degradation of organic material which contributes to the formation of tertiary dentin and sclerosis of dentinal tubules[6]. Moreover, proper selection of the case is necessary to gain satisfactory results. Thorough dental history, clinical examination, and radiographic evaluation are essential for proper diagnosis. In primary teeth, IPC have reported a success rate of 90% or greater regardless of the material used. The purpose of this review is to provide information on recent advances in IPC and new materials used for the treatment [2].

Definition:

1.It is defined as procedure wherein small amount of carious dentin is retained in deep areas of the cavity to avoid pulp exposure, followed by placement of a suitable medicament and restorative material that seals off the carious dentin and encourages pulp recovery - INGLE [7]

2.It is defined as application of a suitable medicament over a thin layer of remaining carious dentin(affected dentin), after deep excavation of infected dentin without exposure to the pulp - MATHEWSON, 1995 [8]

3.A procedure in which only the gross caries is removed from the lesion and the cavity is sealed for a time with a biocompatible material - MCDONALD [9]

4.Procedure in which the nearly exposed pulp is covered with a protective dressing to protect the pulp from additional injury and promote healing and repair via formation of secondary dentin - CDT 2007 GLOSSARY [10]

Classification :

According to the clinical guidelines on pulp therapy in primary and young permanent molars American Academy of Pediatric Dentistry 2009 [11].

1.Vital pulp therapy for primary teeth diagnosed with a normal pulp or reversible pulpitis

Protective liner

-Indirect Pulp Capping

-Direct Capping

-Pulpotomy

2.Non vital pulp treatment for primary teeth diagnosed with irreversible pulpitis or necrotic pulp

-Pulpectomy

Indications :

1. Deep carious lesions, which are close to, but not involving the pulp in vital primary or young permanent teeth.
2. Mild pain while eating.
3. No history of spontaneous, extreme pain.
4. Absence of mobility.
5. When there is a definite layer of affected dentin after removal of infected dentin.
6. Lamina dura and PDL space is normal.
7. Absence of radiolucency in the bone around the apices of the roots or in the furcation [12].

Contraindications:

1. Any signs of pulpal or periapical pathology.
2. Soft leathery dentin covering a very large area of the cavity, in a non restorable tooth.
3. Acute pulpal inflammation.
4. Prolonged spontaneous pain especially at night.
5. Mobile tooth.
6. Discoloration of the tooth.
7. Negative response of electric pulp testing.
8. Pulp exposure.
9. Interrupted or break in lamina dura.
10. Radiolucency about the apices of the roots.
11. Widened periodontal ligament [12].

Diagnosis:

Proper and accurate diagnosis of the incipient stages of a carious lesion can result in its reversal by the use of proper intervention methods.

Methods of Caries Detection:

1.Clinical method / visual-tactile method : A sharp explorer is used to examine dental caries , if slight pull is required to remove the explorer , then the tooth surface will be counted as decayed . This suggestion was given by GV Black[13] in 1924, Simon[14] in 1956, Gillmore[15] in 1982, Marzouk and Sturdevant[16] in 1985. Now it has been proved that the explorer point may fracture the demineralized enamel leading to cavitations. Use of a mirror and blunt probe is the most common method of diagnosing tooth decay. A sharp probe can break the intact tooth surface which may cause a cavity[17].

2.Radiographic methods: Conventional techniques - Bitewing and Intraoral periapical radiograph. These are most frequently used for detecting caries. but, they may cause overlapping of teeth due to faulty angulations and may also miss the initial lesion. In primary dentition, the occlusal surfaces are most susceptible to caries attack, but with the eruption of first permanent molars there is great increase in the incidence of proximal lesions. In such a situation, bitewing radiographs are absolutely required to detect proximal lesions in primary molars.

Advanced techniques - Digital radiography and Xeroradiography. Digital radiography is a filmless technique for intraoral radiograph, utilising very little radiation to which the patient has been exposed and avoids the need for developing films[18]. Xeroradiography has the advantages of producing less radiation and edge enhancement along with its wide latitude of exposure.

3. Tooth separation: Orthodontic modules or bands can be used to achieve slow separation and by separating the teeth one can visualise the proximal and approximal surfaces[19].

Recent Advances in Diagnosis of Dental Caries:

1.Fiber-optic transillumination - It diagnoses approximal lesions in anterior teeth and posterior teeth by utilising fibre-optic light source with the beam reduced to 0.5 mm in diameter[20].

2.Electrical resistance measurement - It is a method of caries detection based on differences in the electrical conductance of carious and sound

enamel. A comparative study was done regarding the accuracy of electronic caries monitor and visual diagnosis for the detection of occlusal caries in primary teeth and was found that it did not provide increased accuracy over visual diagnosis[21].

3.Laser fluorescence device - It utilises fluorescence and light scattering, where the visible light in the blue green region has been used as the light source for the detection of smooth surface and fissure caries at an early stage. A portable diode laser-based system was developed (Diagnodent) for caries detection on occlusal and accessible smooth surfaces[22]. A study done for detection of early carious lesions in primary molar teeth using Diagnodent and was found that this method does not perform well in detecting initial enamel caries lesions[23]. An in vitro study was done to determine the clinical efficiency of Diagnodent in detecting occlusal caries and it was found that is superior to visual and radiographic methods in diagnosing occlusal caries.

4.Caries detector dyes - Silver nitrate, methyl red and alizarin stains have been used to detect carious sites by their change of colour.

5. Ultrasonics - It utilises a sonar device in which a beam of ultrasound waves is directed against the tooth surface and if reflected, is picked up by an appropriate receiver. This method is not for interproximal surfaces but can be readily adopted to easily accessible areas.

6. Magnetic resonance microimaging - It is a noninvasive technique wherein three-dimensional visualisation of the carious lesion, its extent and its relation to other tooth structures can be assessed.

The International Caries Detection and Assessment System (ICDAS) :

ICDAS is a clinical scoring system that is used to detect and assess dental caries[24].

The 'D' in ICDAS stands for detection of dental caries by

i.stage of the carious process
ii.topography (pit and fissure or smooth surfaces)
iii.anatomy (crowns versus roots)
iv.restoration or sealant status.

The 'A' in ICDAS stands for assessment of the caries process by

i.stage (non cavitated or cavitated)
ii. activity (active or arrested).

ICDAS have certain criteria for detecting dental caries in coronal tooth surfaces. The first stage is to classify each tooth surface on whether it is sound, sealed, restored, crowned, or missing (table 1) and the second stage is the classification of the carious status of each tooth surface on an ordinal scale (table 2) [25].

Table 1: IDCAS codes for first stage - to classify tooth surface

Codes for first decision:

Codes	Description
0	Un-restored or unsealed
1	Sealant, partial A sealant that does not cover all pits and fissures on a tooth surface
2	Sealant , full A sealant that covers all pits and fissure on a tooth surface
3	Tooth coloured restoration In the opinion of the dentist, the tooth has a tooth coloured (resin or glass–ionomer cement) restoration
4	Amalgam restoration
5	Stainless steel crown
6	Porcelain or gold or PFM crown or veneer
7	Lost or broken restoration
8	Temporary restoration
9	Tooth does not exist or other special cases. Used in as the following: 9–6 ¼ Tooth surface cannot be examined because of access problem to visualise the tooth surface 9–7 ¼ Tooth missing because of caries (all tooth surfaces are coded 97) 9–8 ¼ Tooth missing for reasons other than caries (all tooth surfaces are coded 98) 9–9 ¼ Un-erupted (all tooth surfaces care coded 99) [25]

Table 2: IDCAS codes for second stage - to classify the carious status of each tooth surface Codes for the second decision:

Codes	Description
0	Sound tooth surface
1	First visual change in enamel; Pits and fissures; smooth tooth surfaces
2	Distinct visual change in enamel
3	Localised enamel breakdown because of caries with no visible dentin or underlying shadow
4	Underlying dark shadow from dentin with or without localised enamel breakdown
5	Distinct cavity with visible dentin
6	Extensive distinct cavity with visible dentin [25].

Caries Associated with Restorations and Sealants - CARS

CARS used to describe the caries adjacent to the restorations or sealants and it's recommended to use this term to prevent complications. Main problem is the difficulties in differentiation among restoration margin discrepancies, secondary caries and residual caries. There are certain criteria for detecting dental caries in restored/sealed teeth (table 3).

Table 3: CARS codes - to detect dental caries in restored/sealed tooth

Codes	Description
0	Sound tooth surface with restoration or sealant A sound tooth surface adjacent to a restoration/sealant margin. There should be no evidence of caries
1	First visual change in enamel When seen wet there is no evidence of any change in colour but after air drying a carious opacity or discoloration is visible that is not consistent with the clinical of sound enamel appearance
2	Distinct visual change in enamel/dentin adjacent to a restoration/sealant margin If the restoration margin is placed on the enamel tooth must be viewed wet. When wet there is an opacity consistent with demineralisation that is not consistent with the clinical appearance of sound enamel . The lesion is still visible when dry. If the restoration margin is placed on dentin, discoloration can be seen that is not consistent with the clinical appearance of sound dentin.
3	Caries defect of <0.5mm (with the signs of code 2) Cavitation at the margin of the restoration/sealant less than 0.5mm, in addition to either an opacity or discoloration consistent with demineralisation.
4	Marginal caries in enamel/dentin/cementum adjacent to restoration/sealant with underlying dark shadow from dentin.Tooth has a shadow of discoloured dentin which is visible through an apparently intact enamel surface or with localised breakdown in enamel but no visible dentin.This shadow may appear as grey, blue, orange or brown in colour and is often seen more easily when tooth is wet.
5	Distinct cavity adjacent to restoration/sealant Visible dentin in the interfacial space with signs of caries as described in code 4 in addition to a gap >0.5 mm in width.
6	Distinct cavity adjacent to restoration/sealant With visible dentin in interfacial space with signs of caries as described in code 4, in addition to a gap >0.5mm.

Techniques:

When the cavity preparation is in close proximity to the pulp but with no visible exposure and does not exhibit any signs or symptoms of pulp degeneration, various one and two stage protocols have been recommended in IPC treatment .

Two stage approach :

All carious dentin is removed from the walls and dentino-enamel junction during cavity preparation. A discoloured layer of deep carious

dentin, which is usually firm, may be left on the floor of the preparation if its removal might cause a pulp exposure[26]. In such a case, a liner such as calcium hydroxide Ca(OH)2 is placed and overlaid by a provisional restoration such as Zinc oxide Eugenol (ZnOE) or Glass Ionomer Cement (GIC). This well-sealed provisional restoration is placed for several months that isolates any remaining caries and bacteria from the oral environment. A recent clinical study conducted by Pereira MA et al in 2017, restoring deep carious lesions using a two-stage indirect pulp capping protocol that used a resin-modified glass ionomer (RMGIC) provisional with and without placing a Ca(OH)2 liner found no clinical benefit [27].In fact, in terms of caries arrestment and dentin remineralization, a study by Alex et al in 2018 suggest the provision of a seal and entombment of residual bacteria to arrest caries progression is more important than initially placed specific base or liner. Although this was a short-term study conducted for 3 months ,it supports the view held by some that the provision of a seal is more important than any specific IPC liner or base that is placed[28]. After several months, assuming all goes well during the provisional trial period (ie, no signs or symptoms of pain or pathology), the patient returns for the second step of the two-stage IPC procedure. The provisional is typically removed, remaining caries is removed to hard tissue, While there are variations in materials and technique and a final restoration is placed. The hope is that some degree of dentin remineralization have occurred along with formation of reparative dentin and dentin bridging, during the time interval between the first and second appointments which allows for residual caries removal during the second appointment without exposing the pulp. While a number of studies and case reports support various two-stage IPC procedures, many dentists are not comfortable leaving residual caries in their cavity preparations. Clearly, a PEARL (Practitioners Engaged in Applied Research and Learning) study conducted in 2007 by Oen KT et al indicated that most dentists prefer to remove all decay initially, while only 20% favoured partial caries removal[29]. These findings are corroborated in a more recent study by Koopaeei MM et al that also found the vast majority of surveyed dentists, when restoring deep carious lesions, preferred complete carious removal to hard dentin at the initial appointment even at the risk of pulp exposure[30].

One Stage Approach :

Typically all or most of the caries is removed at the initial appointment, some type of IPC material is placed in close approximation to but not in direct contact with the pulp, and the final restoration is placed, all in the same appointment. One common technique is to remove only the “infected dentin” and leaving the “affected dentin”. Typically, the affected dentin is then covered with a base or a liner that over time becomes remineralized, forming hard bacteria-free dentin. Use of caries detecting solutions such as propylene glycol, procion, methylene blue to assess the caries status of the dentin during excavation and preparation is the technique preferred by some dentists. Also, some must be aware that it is more difficult to predictably bond directly to deep caries-affected dentin than normal dentin, because caries-affected dentin is different in morphological, chemical, and physical characteristics[33,34]. Many dentists prefer to place base or liner in deep cavity preparations prior to the use of an adhesive system and placement of the final restoration. One technique that has worked well for Y Yoshida et al, when dealing with deep caries-affected dentin is to first disinfect the substrate with a 2% aqueous solution of chlorhexidine digluconate followed by the placement of a RMGIC liner .This liner is placed in a thin layer (≤1 mm) before placing a dentin bonding agent and composite restorative. RMGIC liners have several advantages , including good adhesive and sealing properties via micromechanical and chemical interaction with dentin[35].They are simple to mix and place and they release high sustained levels of fluoride[36] that have significant antimicrobial properties[37,38] and low solubility, and exhibit a favourable modulus of elasticity, coefficient of thermal expansion and contraction (similar to that of dentin). In addition, these liners have been shown in study conducted by John F Weston, to help reduce gap formation and microleakage.While there is scientific evidence supporting the use of RMGIC liners in close proximity to (but not in direct contact with pulp), their use as direct pulp capping agents is generally contraindicated.The remaining dentin thickness(RDT), which is very difficult to access clinically, has an effect on the pulpal response to any indirect pulp capping material[39].

Polyamide Burs or Smart Burs:
After gaining access to the carious layers, polyamide burs is used to remove only the infected dentin.The burs wears off when reached the affected dentin. The risk of pulp exposure is reduced by using these burs. Ca(OH)2 will be placed once the caries excavation is done and then GIC or reinforced ZnOE cement is built up as base, then final restoration will be placed using resin composite[40].

Guidelines For Stepwise Excavation:
Deep lesions, if treated by a single and terminal excavation, are likely to result in pulp exposure.Evaluating them by radiograph, the dentinal lesion involves three-fourths or more of the dentin thickness.
1.No history of pretreatment symptoms such as spontaneous pain and provoked pulpal pain. However, mild to moderate pain on thermal stimulation is accepted.
2.Positive pulp sensibility tested by an electric pulp tester, thermal stimulation, or test cavity. Pretreatment radiograph that rules out apical pathosis[40].
3. Finish the peripheral excavation of the cavity followed by a central excavation removing the outermost necrotic and infected demineralized dentin, in order that a provisional restoration can be properly placed.
4.Do not excavate as closely as possible during the first step, thereby reducing the risk of pulp exposure.
5.Select a provisional restorative material based on the length of the treatment interval, ranging between 6 months and 8 months.
6.The final excavation is often less invasive than expected, as a result of the altered dentinal changes gained during the treatment interval[40].

Procedure of Application of Pulp Capping Agent:
Most frequently used material for indirect pulp therapy is Dycal (calcium hydroxide). This is supplied as a two-paste system, one containing base(titanium dioxide in glycol salicylate) and one containing catalyst (Ca(OH)2 and zinc oxide in ethyl toluene sulfonamide). One drop of each paste is dispensed in the mixing pad. Now the catalyst paste is lifted with a blunt probe and carried to the cavity where it is spread all over the cavity floor only. In similar fashion the base paste is taken to the cavity and the two pastes are then mixed in the cavity and spread evenly with the help of ball burnisher. This not only evenly mixes the pastes but also allows a uniform thickness to be attained in the cavity. Although Dycal can be mixed on the pad and carried to the cavity also the above described method is more convenient as Dycal sets very fast after mixing[40].

Materials used in IPC (table 4):

Table 4 :Advantages and disadvantages of materials used in IPC:

S.no	Materials	Advantages	Disadvantages
1	Ca(OH)2	-Biocompatible -Antimicrobial activity -Induction of calcified barrier -Promotes healing and repair -Stimulates fibroblasts -Inexpensive -Easy to use[2]	-May dissolve after one year -Poor sealing properties[2]
2	RM GIC	-Biocompatible -Antimicrobial activity -Ability to bond to enamel and dentin -High mechanical strength -Uptake and releases fluoride[2]	-Cytotoxic effect -Reduced wear resistance[2]
3	MTA	-Biocompatible -Antimicrobial activity -Increased marginal adaptation thus has less leakage -Improved sealing properties -Induced osteogenesis -Promotes healing[2]	-Discoloration -Prolonged setting time -High cost[2]
4	Dentin	-Effective barrier against germs, oral	-Toxic to living tissue

	bonding agents	fluids, ions, and chemicals getting into the contact between the teeth and the material to be filled. - The tendency of objects or surfaces to adhere to each other due to physical forces in hard tissues[4]	-The production of calcific bridges is absent. -In vivo investigations have shown that placing an adhesive resin directly on the point of exposure of pulp or dentin thickness of less than 0.5 mm promotes blood vessel dilation and congestion, and also chronic inflammatory pulp response[4].
5	Biodentine	-Biocompatible -Antimicrobial activity -Increased marginal adaptation -High bond strength -Can induce odontogenic differentiation and formation of reparative dentin[2]	-High cost[2]
6	TheraCal	-Enhanced physical properties -Low solubility -Improved sealing ability -High calcium release -Induced formation of dentin bridge[2]	-Opaque whitish colour[2]

1.Calcium hydroxide : Hermann introduced Ca(OH)2 in 1921. He also found that it may be used to heal an exposure site in 1930 . It has been utilised successfully in the clinical practice in the form of powder, paste, and cement to aid in the creation of reparative dentin as well as the preservation of essential pulp, mineralization, and bacterial growth inhibition.

2.RMGIC : When utilised in close proximity with the pulp but not in direct contact, glass ionomer provides an effective resistance against bacteria and it has good biocompatibility.

3.Mineral Trioxide Aggregate (MTA) : Torabinejad in the 1990s discovered MTA. It has become available as various types of dental materials. During the setting process initial PH will be 10.2 which increases up to 12.5 during the first few hours [4].

4.Dentin bonding agents : According to Miyakoshi, dentin bonding agents give greater adherence to peripheral hard tissues. However, they have poor prognosis because of the cytotoxic effect and the lack of calcific bridge development[4].

5.Biodentine : It is a novel bioactive cement that has mechanical qualities similar to dentin and can be used to replace dentin. It also enhances the production of tertiary dentin and has a beneficial effect on vital pulp cells .

6.TheraCal - LC : It is a light-cured, resin modified calcium silicate based liner as well as a protective base/liner beneath composites, amalgams, and other base materials for both pulp capping methods. This material acts as a dental pulpal complex insulator, barrier, and protectant[4].

Sequelae/Outcome of IPT :

Three distinct types of new dentin formation take place,

1. Cellular fibrillar dentin - first 2 months.
2. Globular dentin - 3 months.
3. Tubular dentin (uniform mineralized dentin): One-fifth of reparative dentin formation begins in less than 30 days . After 3 months, 0.1 mm is formed[40].

Comparison and success rate of IPC materials:

Marchi et al in 2006 evaluated clinical and radiographic changes in primary teeth submitted to IPC over a period of 2 years in which twenty seven primary molars with deep caries, but without preoperative signs of irreversible pulpitis, were treated with IPC materials. The teeth were randomly divided into two groups, according to

the material used: (a) a Ca(OH)2 liner (b) GIC. After 48 months, Group-1 showed a success rate of 88.8% and Group-2 showed 93%.The results of this study suggested that IPC in primary teeth arrests the progression of the underlying caries, regardless of the material used as a liner[41].Coll JAS in 2008 has been shown that IPT have a lower cost, higher success long-term, better exfoliation pattern, and better success treating reversible pulpitis than pulpotomy[42]. Korwar A et al in 2015 analysed study done by Marchi et al and Coll JAS al , after which they studied the pulp response of two high fluoride releasing materials silver diamine fluoride and Type VII GIC when used as IPC agent and concluded that both are equally effective in tertiary dentin formation[43].Mathur et al in 2017 analysed the previous studies and compared the efficacy of CH (setting type), GIC (Type VII), and MTA as IPC agent and found that all are equally stimulating the formation of mineral .The clinical and radiographic success at 12 months with 95 teeth was found to be 93.6% (29/31) with CH (setting), 97% (32/33) in GIC (Type VII), and 100% (31/31) in MTA [44]. The success rate of CH as an IPC agent is significantly lower in comparison to Theracal and Biodentine at 2 years follow-up. With improved physical and chemical qualities, calcium silicate based materials such as Biodentine and Theracal are proven to be superior to calcium hydroxide[45]. Biodentine exhibited the highest success rate as compared with calcium hydroxide and RMGIC liner in conjunction with 2% chlorhexidine gluconate as a disinfecting solution and also the choice of better IPC material [46].Another study by George et al. [47] in 2021, demonstrated that there was a significant difference between MTA and dycal in depositing reparative dentin and no failure rates were seen in the MTA group[48]. Long term recall (2- to 4-year) studies showed a high success rate from 70-90% for IPT. Since IPT requires no pulp entry, cases of failure are expected to occur in a short period of time, and are reflected in terms of clinical or radiographic evaluations. In addition, the failure of IPT is more likely to be as a result of incorrect diagnosis of the pulp condition. The overall proportion of teeth was 78% that had a successful outcome with IPT after the final evaluation (up to 60 months)[49].

Glossary :

IPC - Indirect Pulp Capping
IPT - Indirect Pulp Therapy
DPC - Direct Pulp Capping
CDT - Current Dental Terminology
AAPD - American Academy of Pediatric Dentistry
PDL - Periodontal Ligament
ICDAS - The International Caries Detection and Assessment System
CARS - Caries Associated with Restorations and Sealants
RMGIC - Resin Modified Glass Ionomer
RDT - Remaining Dentin Thickness
GIC - Glass Ionomer Cement
ZOE - Zinc Oxide Eugenol
Ca(OH)2- Calcium Hydroxide
MTA - Mineral Trioxide Aggregate

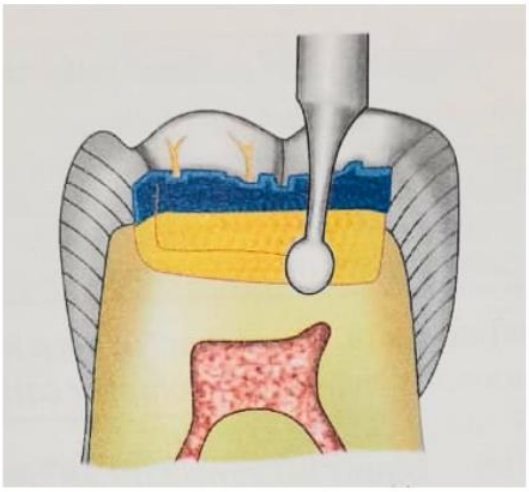

Fig A : remove the caries with a slow speed bur

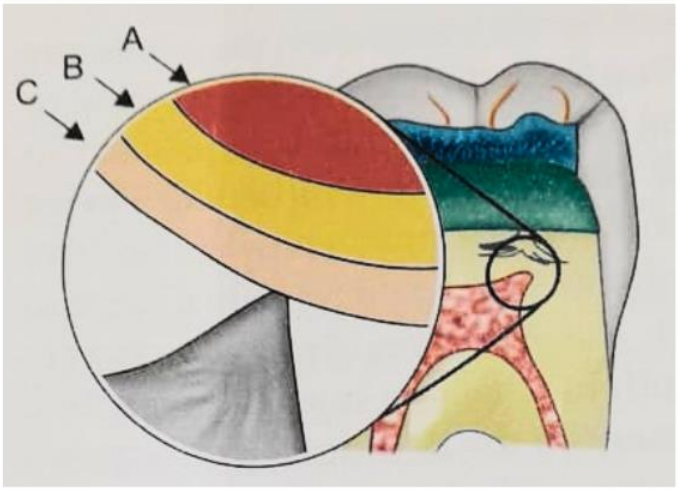

Fig B : Three layers of carious dentin:
a. Necrotic tissue/infected dentin
b. Leathery infected dentin
c. Affected dentin

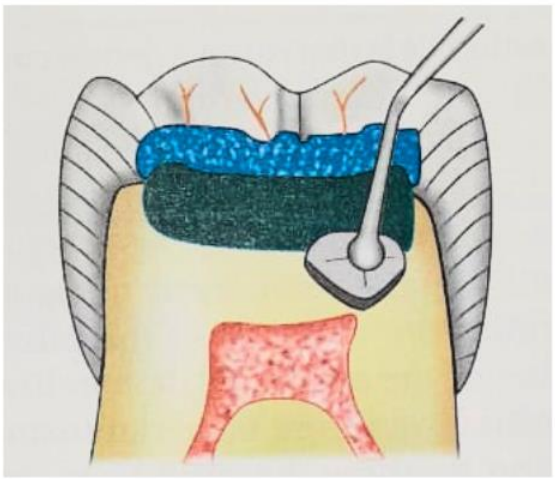

Fig C : place calcium hydroxide over the carious dentin

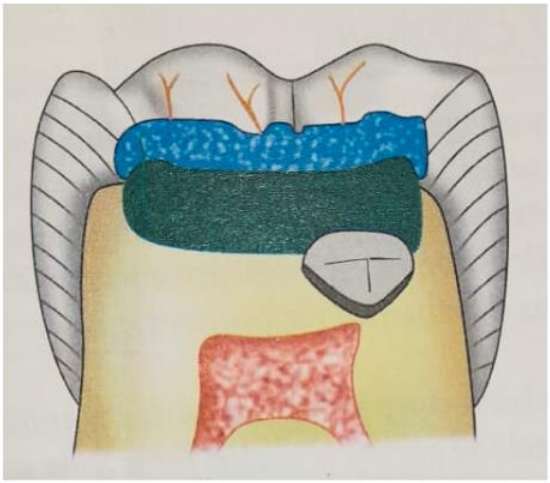

Fig D : Final restoration In place

Conclusion:

IPT is a conservative dental procedure indicated for teeth having deep caries with no signs and symptoms of pulp necrosis or infection which is recommended as the preferred treatment approach in primary teeth by AAPD as it preserves the tooth vitality and has shown high success rate compared to pulpotomy. It is also essential to note that the success rate of IPT depends on accurate diagnosis and case selection, proper technique and material selection, patient compliance and follow-up.

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