Minimal Extension for Maximal Results - Review on Minimal Intervention Paediatric Dentistry

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Abstract

Background: Recent advances in dentistry have transformed approach to the diagnosis and management of dental caries. This article review's the scientific basis for early diagnosis of dental caries, remineralization of tooth structure and reduction of cariogenic bacteria by using minimally invasive techniques.

Methodology: Literature survey was carried out in electronic databases such as PubMed, COCHRANRE library, SCOPUS, Science Direct, EMBASE, using key words such as "Minimally Invasive Dentistry, recent advances in paediatric dentistry, smart materials and techniques". The literature search revealed 562 articles of which 47 were selected after reading the full text articles.

Conclusions: Modern advancements have led to the development of minimally invasive paediatric dentistry. Though emerging technology will aid in shift to Minimal invasive dentistry but there are still technological, economic and knowledge barriers to their complete adoption into the paediatric dental practice.

Keywords: Advanced Diagnostic Aids; Minimal Invasive Dentistry; Recent Advances in Paediatric Dentistry

Introduction

Though the concept of MID has been stressed upon for a decade, uptake of this philosophy has not been at the global level. MID should be the standard of care in paediatric restorative dentistry, as it avoids extensive restorative interventions as well as supervised neglect. As the dental profession worldwide faces the challenges of dealing with high rates of dental caries in paediatric patients, it is even more important to incorporate these concepts into paediatric dental practice to deal with the challenge of preventive and therapeutic management of dental caries in children [1].

Search criteria

A survey was conducted to find out the available literature on the topic of minimal invasive dentistry. the MeSH terms used for searching were 'minimal invasive dentistry', minimal dentistry, ART, advances in paediatric dentistry, smart materials and regenerative dentistry. the search engine included was google in searching the medical and electronic databases. the electronic databases searches were the, PubMed, Scopus, science direct, web of science and Cochrane library.

Articles published in between the years of 2000 to September 2021 were included in the literature survey.

Selection criteria

Qualitative assessment was done in selecting the articles which were available in the databases.

Inclusion criteria

- Studies on characteristics of minimal intervention dentistry
- Studies on recent advances in dentistry
- Investigation reports, clinical trials and randomized control trials

The literature search revealed 562 articles of which 89 articles were selected after reading the title and abstracts. After reading the full text articles 59 articles matching the inclusion criteria were selected for the review.

Definition

Minimum (or minimal) intervention dentistry (MI) can be defined as a philosophy of professional care concerned with the first occurrence, earliest detection, and earliest possible cure of disease on micro (molecular) levels, followed by minimally invasive and patient-friendly treatment to repair irreversible damage caused by such disease [1,2].

Principles of minimal intervention paediatric dentistry [MIPD] [3,4]:

Figure 1: Principles of Minimal Intervention Paediatric Dentistry.

Recognition: Early identification and assessment of risk factors for dental caries

Detection of caries [5]

Evaluation of individual caries risk cannot be separated from the actual diagnosis of carious lesions. It is essential to assess the risk factors for the correct choice of preventive, interceptive, or therapeutic care.

Figure 2: Flow-chart of assessment of initial carious lesions.

Visual examination [6]

- Visual examination is not an ideal method to diagnose dental caries as most of the lesions go undetected.
- Clinical accuracy of caries detection by visual examination is only 25-30%.

Tactile examination with a probe [7]

- Use of explorer can cause irreversible damage to the tooth structure which can be remineralized,
- Dr.Nigel B.Kidd: "SHARP EYES BUT BLUNT PROBE".

Another suggested method is assessment of the incidence of discontinuities in enamel or micro-cavitations evaluated through

WHO/CPI/PSR probe which has a ball end with a sphere measuring 0.5 mm in the extremity [8].

Figure 3: Probe with round tip.

ICDAS system [9]

Cariou lesions are classified according to the site of occurrence in this system occlusal (site 1), proximal (site 2), and cervical (site 3), then further classified according to their stage.

ICDAS Code	Criteria for visual lesion detection	Degree of severity of lesion	SiSta* stage	Therapeutic options
0	Sound surface			Not necessary
1	Earliest optical change, visible on drying enamel	Demineralisation in outer third of enamel	0	Minimal intervention; non-invasive care, remineralisation or sealant
2	Clear enamel change; white or brown blemishes, visible without drying	Demineralisation reaching the inner third of enamel, possibly the ADJ		
3	Localised break in enamel	Demineralisation of outer third of dentine	1 and 2	Minimal intervention; adhesive ultra conservative restoration
4	Dentine not visible	Demineralisation of middle third of dentine, no weakening of dental crown structure		
5	Enamel opaque or greyish, suggestive of an underlying dentine lesion, with or without enamel cavitation	Demineralisation of middle third of dentine, weakening of dental crown structure	3 and 4	Operative dental care; functional crown restoration with or without cusp coverage
6	Dentine cavity	Demineralisation of inner third of dentine, undermining of cusp structure and support		

Figure 4: Criteria for visual detection of carious lesions [ICDAS] and SiSta classification.

Contribution of magnification to minimize intervention [10]

Improved visualization of the operator potentially reduces the number of operative treatments. At higher magnification, signs of inactive lesion like dark colour, no retention of dental plaque, shininess encourage postponement of such operative treatment.

Figure 5: Normal view and magnified view of dental caries.

Caries risk assessment [11]

Caries Risk: The probability that a specific number of new lesions will develop and/or specific number of existing lesions will progress over a specified period of time.

Caries risk assessment model	Main characteristics	Age group	How results are presented
CARIOGRAM [49]	Software program in which the following risk factors are considered: caries experience, related diseases, diet content and frequency, amount of plaque, mutans streptococci, fluoride program, saliva secretion, buffer capacity, and the clinical judgment of the dentist.	All age groups	Provides the chance that an individual has to avoid new carious lesions
CAMBRA —caries management by risk assessment [50]	Form based on disease indicators, biological risk factors, and protective factors. The variables investigated vary according to the individual's age	Two forms are available according to the individual's age: (1) preschool children (0–5 years old) and (2) age 6 years old through adulthood	Classifies individuals into four caries risk categories: "low", "moderate", "high", and "extreme"
CAT —caries-risk assessment tool [51]	Form based on caries risk indicators assessed by clinical conditions, environmental characteristics, and general health conditions	Two forms are presented according to individual's age: (1) preschool children (0–5 years old) and (2) school children and adolescents (≥ 6 years old)	Classifies individuals in three caries risk categories: "low", "moderate", and "high"
OHRA —oral health risk assessment [52]	Form based on risk factors, protective factors, and clinical findings	Young children	Classifies individuals in two caries risk categories: "low" and "high"
NUS-CRA —National University of Singapore caries risk assessment [53]	A software program which takes into account clinical factors and sociodemographic factors	Preschool children	Provides the chance that an individual has to develop new carious lesions

Figure 6: Caries Risk Assessment.

Diagnostic aids [12]

- Illumination methods:

- Fiber-optic transillumination (FOTI)
- Wavelength dependent FOTI
- Digital imaging FOTI (DIFOTI).
- Midwest caries
- Endoscopy:
 - Endoscopically viewed filtered fluorescence
 - White light fluorescence
 - Videoscope
- Intraoral television camera (IOTV)
- Electrical conductance measurement (ECM)
- Radiography
 - Digital imaging radiography
 - Subtraction radiography
 - Computed tomography (CT)
 - X-ray microtomography
 - Polarization sensitive optical coherence tomography
 - Transverse microradiography (TMR)
 - Tuned aperture CT (TACT)
- Lasers
 - Quantitative light-induced fluorescence (QLF)
 - Diagnodent
- Species specific monoclonal antibodies
- Cariescan

Identification of oral micro flora

Caries activity tests [13,14]

Caries activity tests rely on the notion of a specific odontogenic infection.

Specific bacterial predominance is attributed to its acidogenic and aciduric nature after a selective growth benefit over the other non-acid tolerant organisms. Identification of caries susceptible children through basic diagnosis techniques is not feasible, thus, caries activity tests have been evolved to avert this difficulty.

Reduction and re-orientation: To eliminate or minimize risk factors of dental caries

Elimination of risk factors [15]:

Non-invasive interventions deal with prevention of dental caries and maximum conservation of demineralized but non-cavitated enamel and dentin. It is possible by eliminating bacteria and their by-products and by aiding remineralization process i.e., fluorides

- Oral health education
- Fluoride in prevention of dental caries
 - Professionally applied topical fluorides
 - Self-applied topical fluorides
 - Fluoride mouth rinses
 - Fluoride dentifrices.

Chemical plaque control agents

- Enzymes
- Antibiotics
- Bisbiguanide antiseptics
- Quaternary ammonium compounds
- Detergents
- Oxygenating agents
- Chlorhexidine
- Acidified sodium chlorite
- Preventive/prophylactic Measures like Chewable tooth brush.

This disposable tooth brush comprised of xylitol, flavouring agent, aqua, and polydextrose. Not recommended below age of 6 years [16].

Modern methods for caries control [17]:

- Bacterial transplantation or replacement in the oral cavity
- Ozone disinfection
- Phyto therapeutic agents

Figure 7: Chewable tooth brush- Fuzzy brush.

- Antimicrobials encapsulated in controlled-release microcapsules
- Sustained-release materials and smart materials
- New biomaterials that buffer pH and that have impervious margins
- Combination therapy (propolis/fluoride/mineral concentrates).

Ecological approaches for caries prevention [18]:

- Antimicrobial Peptides - Natural (lactoferrin, cathelicidins, histatins, defensins),
- Specifically (or Selectively) Targeted Antimicrobial Peptides [19].

STAMPs	Organisms inhibited
C16G2	<i>S. mutans</i>
SM6(L1) B33	<i>S. mutans</i>
SM7	<i>S. mutans</i>
2A4,2B1,2B5,2B7,3H5,4B9	<i>S. mutans</i>
LL-37	<i>S. mutans</i> , <i>Lactobacillus</i> , <i>Actinomyces viscosus</i> , <i>Actinobacillus actinomycetemcomitans</i>
K4-S4 (1-15a)	<i>Fusobacterium nucleatum</i> , enteric <i>Escherichia coli</i> , <i>S. mutans</i> , <i>Lactobacillus</i> , <i>Actinomyces viscosus</i> .
dhvar4a	<i>Fusobacterium nucleatum</i> , enteric <i>Escherichia coli</i> , <i>S. mutans</i> , <i>Lactobacillus</i> , <i>Actinomyces viscosus</i> , <i>Actinobacillus actinomycetemcomitans</i>

Figure 8: List of few currently developed peptides against oral infections.

- Probiotics: “Substrate that is selectively utilized by host Microorganisms conferring A health benefit” [Gibson., et al. 2017]

- Prebiotics: These are animate microorganisms which are administered in Adequate amounts to confer a health benefit on the host” [Sanders, 2008]
- Sugar Polyols
- Quorum-Sensing Targets
- Natural Products
- Replacement Therapy with “Designer” Bacteria
- Recent Approaches - Compounds affecting bacterial virulence proteins i.e., Calcium phosphate-Osteopontin particle, Nanoparticles Graphene oxide.

Regeneration: To arrest and converse incipient lesion

Since the 1980s, it has been an established belief that fluoride action is predominantly through its topical but not systemic as previously thought.

The proposed four mechanisms of fluoride are [20]:

- Inhibits demineralization
- Enhances remineralization
- Inhibit essential bacterial activity.
- The long-term benefit is through intraoral reservoirs which are formed after fluoride application through toothpaste, varnish or restorative material and is then released into the saliva overtime.

Risk category (ages 0 to 2 years)	Diagnostic				Preventive intervention
	Periodic oral exams	Radiographs	Saliva test	Fluoride	Xylitol
Low	Annual	Posterior bitewings at 12-24 month intervals if proximal surfaces cannot be examined visually or with a probe	Optional baseline	In office: no Home: Brush twice a day w/ smear of F toothpaste	Not required
Moderate	Every six months	Posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Recommended	In office: F varnish initial visit & recalls Home: Brush twice a day w/smear of F toothpaste Caregiver: OTC sodium fluoride treatment rinses	Child: xylitol wipes Caregiver: two sticks of gum or two mints four times a day
Moderate; non-compliant	Every three to six months	Posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit & recalls Home: Brush twice a day w/smear of F toothpaste combined w/smear of 900 ppm calcium- phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses	Child: xylitol wipes Caregiver: two sticks of gum or two mints four times a day
High	Every three months	Anterior (#2 occlusal film) and posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit & recalls Home: Brush twice a day w/smear of F toothpaste combined w/smear of 900 ppm calcium- phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses	Child: xylitol wipes Caregiver: two sticks of gum or two mints four times a day
High; non-compliant	Every one to three months	Anterior (#2 occlusal film) and posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit & recalls Home: Brush twice a day w/smear of F toothpaste combined w/smear of 900 ppm calcium- phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses	Child: xylitol wipes Caregiver: two sticks of gum or two mints four times a day
Extreme	Every one to three months	Anterior (#2 occlusal film) and posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit & recalls Home: Brush twice a day w/smear of F toothpaste combined w/smear of 900 ppm calcium- phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses	Child: xylitol wipes Caregiver: two sticks of gum or two mints four times a day

Figure 9: Caries management protocol for 0-2 years old.

Risk category Ages 3 to 6	Diagnostic			
	Periodic oral exams	Radiographs	Saliva test	Fluoride
Low	Annual	Posterior bitewings at 12-24 month intervals if proximal surfaces cannot be examined visually or with a probe	Optional Baseline	In office: no Home: Brush twice a day w/ pea size of F toothpaste
Moderate	Every 6 months	Posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Recommended	In office: F varnish initial visit and recalls Home: Brush twice a day w/ pea-size of F toothpaste Caregiver: OTC Sodium Fluoride treatment rinses
Moderate; non-Compliant	Every 3-6 months	Posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit and recalls Home: Brush twice a day w/ pea-size of F toothpaste combined w/ pea-size of 900 ppm calcium-phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses
High	Every 3 months	Anterior (#2 occlusal film) and posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit and recalls Home: Brush twice a day w/ pea-size of F toothpaste combined w/ pea-size of 900 ppm calcium-phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses
High; non-Compliant	Every 1-3 months	Anterior (#2 occlusal film) and posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit and recalls Home: Brush twice a day w/ pea-size of F toothpaste combined w/ pea-size of 900 ppm calcium-phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses
Extreme	Every 1-3 months	Anterior (#2 occlusal film) and posterior bitewings at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe	Required	In office: F varnish initial visit & recalls Home: Brush twice a day w/ pea-size of F toothpaste combined w/ pea-size of 900 ppm calcium-phosphate paste leave-on at bedtime Caregiver: OTC sodium fluoride treatment rinses

Figure 10: Caries management protocol for 3-6 years old.

Fluoride [21]:

- Silver Diamine Fluoride - SDF-
- Silver Nitrate + Fluoride - SNF
- Nano Silver Fluoride – NSF.

Silver diamine fluoride [22]

Silver diamine fluoride 38% (Advantage Arrest, Elevate Oral Care) has been shown to be effective for on-label uses (treatment of dentinal hypersensitivity), as well as some off-label uses (arresting caries in children and adults, and caries diagnosis).

Mechanism includes Occlusion of dentinal tubules, anti-bacterial action, prevention of collagen and mineral degradation.

Need for shift to non- fluoride strategies [23]:

- Fluoride's limited effect on pit and fissure caries.
- Potential adverse effects (e.g., fluorosis) due to overexposure to fluoride
- Fluoride toxicity.
- Not a capable alternate in active disease process.
- Certain countries do not have fluoridated products.

The above disadvantages demand the need for non-fluoride remineralizing agents.

Non-fluoride remineralizing agents [23]:

Technology	Commercial Product
Biomimetic systems	Curodont Repair / Curodont Protect Apagard toothpaste / Desensin oral rinse
Agents that deliver calcium and phosphate ions to tooth surface	
1. Casein phosphopeptide stabilised calcium phosphate (rcalcentT, CPP-ACP)	Tooth mousse / MI paste cremes, Trident white sugar-free gum, MI paste ONE toothpaste
2. Unstabilised amorphous calcium phosphate (ACP, enamel TM)	Enamelon toothpaste, Enamel Pro varnish
3. Bioactive glass containing calcium sodium phosphosilicate (Nova Min TM)	NovaMin toothpaste
4. Functionalised β -tricalcium phosphate	Clinpro toothpaste, Clinpro white varnish
Agents that modify the biofilm	
1. Arginine bicarbonate and urea	Colgate – Palmolive (1.5 % arginine)
2. Ozone gas	HealOzone, OZOTOP
Agents that neutralise organic acids	
1. Calcium glycerophosphate	
2. Calcium phytate	
3. Calcium lactate	
Anti-plaque agents	
1. Antimicrobials and antibiotics chlorhexidine triclosan	Listerine
2. Xylitol	Xylitol chewing gums, Xylitol gummy bear snacks, Xylitol syrups, Xylitol toothpaste, Xylitol mouth rinse
3. Metallic salts	

Figure 11: Non fluoride enamel remineralizing technologies.

Repair versus replacement

- Repair is indicated mainly in the occasion of results which are clinically unsatisfactory and no longer adequate. Repair is a minimally invasive approach i.e., addition of restorative material to an existing restoration.
- Replacement, if indicated, is for a more severe problems where intervention is necessary, and a repair is not possible; it is the removal of the restoration in- toto [24].

Non - cutting strategies

Atraumatic restorative treatment [25]:

The Atraumatic Restorative Treatment (ART) is a non - invasive procedure based on removing carious tooth tissues using hand instruments and restoring it with a glass ionomer cement.

Figure 12: Atraumatic restorative treatment.

Halls technique [26]:

The Hall technique is a recent method of biological sealing for carious lesions in primary molars. The rationale being creation of a non- nutritive environment for bacteria by sealing them from oral environment. Recent literature suggest that Hall technique is measured and a promising restorative option with high acceptability and longevity; with low failure rate for managing carious primary molars. However, it should be chosen in restricted cases.

Chemomechanical caries removal [27]:

Chemo mechanical caries removal (CMCR) is another non-invasive technique, eradicating infected dentine through principal of dissolution via a chemical agent. The advantages of being the inconvenience of using burs and local anaesthesia is evaded, thus causing less discomfort and even conserving healthy dental structure.

Conservative operative management strategies

The international caries consensus collaboration (ICCC) recommendations on carious tissue removal [28]:

- Nonselective removal to hard dentine (formerly complete excavation or complete caries removal).
- Selective removal to soft dentine is recommended in deep cavitated lesions.

- Stepwise removal of carious tissue removal in two stages.
- A last strategy is not removing any carious tissue at all.

Lately, conservative forms of operative intervention have been endorsed that concentrate on the removal of carious dentin thus preserving maximal sound tooth structure.

Figure 13: Affected dentin Vs Infected dentin.

Layers of a dentine caries lesion. The 'outer carious dentine' or 'infected dentine' is soft and infected and should be removed. The 'inner carious dentine' or 'affected dentine' can remineralise and should be retained. Smart prep burs can be used to selectively remove infected dentin [32].

Tooth cutting strategies [29]:

There are several clinical technologies available for cutting teeth and removing caries.

Modifications in the burs [30]:

Fissurotomy bur: three types:

- Original fissurotomy
- Micro STF and
- Fissurotomy Micro NTF
 - Micro Diamond Prep System (Brasseler USA): set of eight burs.

Mechanism	Dental substrate affected	Tooth-cutting technology
Mechanical, rotary	Sound or carious enamel and dentine	SS, CS, diamond, TC and plastic burs*
Mechanical, non-rotary	Sound or carious enamel and dentine	Hand instruments (excavators, chisels), air-abrasion, air-polishing**, ultrasonics, sono-abrasion
Chemomechanical	Carious dentine	Caridex™, Carisolv™ gel (amino acid-based), Papacarie® gel (papain-based), pepsin-based solutions/gels
Photo-ablation	Sound or carious enamel and dentine	Lasers
Others	bacteria	Photo-active disinfection (PAD), ozone

Key: SS = stainless steel; CS = carbon steel; TC = tungsten carbide; * = works only on carious dentine; ** = used for stain-removal³

Figure 14: Overview of different tooth cutting strategies.

- Polymer Caries Removal Burs (SMART BURS): Slow speed rotary handpiece at 500-800 rpm.
- Ceramic burs: The CeraBurs are all- ceramic round burs made of alumina-yttria stabilized zirconia. They are available in different diameter sizes.

Designs of cavity preparations [31]:

A systematic review of clinical studies pertaining to three specific conservative operative techniques was published in 2001, including a review of proximal-only, “tunnel,” and preventive resin restorations (PRRs).

- Tunnel preparations/Open/Close/Partial/Blind
- Saucer preparations
- Box only preparations
- Slot or Minibox cavity Preparations
- Microchip cavity preparation
- Full box cavity preparation.

Modified cavity preparations [32]:

Figure 15: Modified cavity preparations.

Sonic abrasion [33]:

Sono-abrasion is a technique of selective preparation of enamel and dentine offering excellent efficacy and safety. This technology is alternative to rotary instrumentation. It is compatible with direct and indirect adhesive restoration techniques.

Type of tip	Use
1 entirely abrasive tip: pointed cone shape	Prevention (sealant) Opening and preparation of fissures
1 entirely abrasive tip: round with collar shape	Occlusal mini-cavities, Access to dentinal lesions
2 MD 2-surface tips: half round or hemispherical shape	Preparation of approximal mini-cavities Finishing cavity margins Selective superficial abrasion
2 MD 2-surface tips: approximal box shape	Preparation of approximal boxes Direct restorations and inlays, onlays
2 MD 2-surface tips: hemi-ogivale shape	Interproximal clearing Preparation of approximal margins Preparation of veneers
2 MD 2-surface tips: lance shaped blade	Access and interproximal clearing Stripping and shaping Trimming and finishing restorations

Key: MD = mesial/distal; Two-surface = one surface smooth, one surface diamond-coated.

Figure 16: Sonic abrasive tips.

Air abrasion [34]:

Air abrasion eradicates the needless destruction of sound tooth structure associated with traditional restorative techniques while leaving the tooth ideally conditioned for the beneficial caries-inhibiting and strengthening properties of bonded restorations.

FACE (Fluorescence-aided caries excavation) [35]:

With fluorescence aided caries excavation areas exhibiting orange-red fluorescence can be selectively removed with the bur. It is more effective in removing infected dentin reducing loss of healthy tooth structure.

Lasers for pediatric patients [36]:

Children are the first in line to receive dental laser treatment and based on the micro dentistry painless drilling. Laser-supported dental diagnosis and treatment is key for treating children successfully according to the modern research in paediatric dentistry [41].

Ozone [37]:

Its ability to arrest and reverse carious lesions in a predictable way opened up a new chapter in minimal intervention dentistry. Moreover, its efficacy in decreasing resistant poly microbial root canal flora seems very promising.

Caries Severity Index	Diagnosed Reading	Clinical diagnosis	Radiographic interpretation	Treatment plan
1	<10	May be a sound tooth	Normal	10 Sec O ₃ /Seal Fissures if indicated with GIC or flowable composite
2	10-16	White spot lesions	Normal (lesion not seen on x-rays)	40 sec O ₃ and remineralisation therapy Air abrasion and/or seal fissures
3	20-24	Carious lesion at EDJ	May not be visible on x-rays	Air abrasion/etch/40 sec O ₃ therapy and restoration with GIC/composite
4	25-29	Caries involving 1-2mm of dentin	May/may not be visible on X-rays	Remove infected dentin, leave affected dentin. Etching - 60 sec O ₃ therapy and restore with GIC/composite/Light cure GIC
5	>30	Caries involving >2mm of dentin	Mostly visible on X-Rays	Remove infected dentin to leave affected dentin, ozone exposure for 60 sec. depending on remaining dentin thickness liner/base and restoration.
6	>99	Deep carious lesion, may/may not involve pulp.	Visible on x-rays and assessing pulp vitality	If vital, indirect pulp capping is advised. Expose O ₃ for 120 sec and seal with GIC. After 1 month, reassess and If remineralisation is evident, it can be restored with a permanent restoration.

Recommended ozone concentration (O₃): 3.5-5 g/ml& flow Rate: 0.5-1 L/min.

Figure 17: Clinical applications of ozone.

Restorative therapy

Pit and fissure sealants and preventive resin restoration [38]:

The idea of prophylactic fissure sealants or preventive resin restoration was first reported by Simonsen and Stallard (1977). Preventive resin restoration utilizes the non - invasive treatment modalities for borderline or questionable caries. It is a natural extension of the use of occlusal sealants. It integrates the preventive approach of the sealant therapy for caries - susceptible pits and fissures with the therapeutic restoration of incipient caries with composite resin.

Age ranges for extended sealant application:

A high percentage of occlusal lesions occurred in the first 3 years after eruption.

- 3-4 years of age for the primary molar sealant application
- 6-7 years of age for the permanent first molar
- 11-13 years of age for the permanent second molar.

Bioactive and biomimetic materials [39]:

A bioactive material is one that forms a surface layer of an appetite-like material in the presence of an inorganic phosphate solution. The calcium silicate- and calcium aluminate-based cements a wide range of calcium-based or calcium-containing materials that demonstrated bioactivity.

Sustained release materials, responsive release and smart materials [40]:

Smart materials are materials that have properties which can be altered in a controlled fashion by stimuli like stress, temperature, moisture, pH and electric or magnetic fields.

Smart composites

Aaron S. Posner first described AMORPHOUS CALCIUM PHOSPHATE (ACP) in 1960s. ACP has been evaluated as a filler phase in bioactive polymeric composites. In addition to excellent biocompatibility, the ACP containing composites release calcium and phosphate ions into saliva. When the pH level in the mouth drops below 5.8, these ions merge within seconds to form a gel.

Self-healing composites

One of the first self-repairing or self-healing synthetic materials reported is resin-based epoxy system which contained resin filled microcapsules. If a crack occurs in the epoxy composite material, some of the microcapsules are destroyed near the crack and release the resin. The resin subsequently fills the crack and reacts with a Grubbs catalyst dispersed in the epoxy composite, resulting in a polymerization of the resin and a repair of the crack.

Silver nanoparticles in dental biomaterials [41]:

Several studies have shown that nanoparticulate form of silver possesses an inhibitory effect against many bacteria and fungi, including *S. mutans*, *C. albicans*, *P. aeruginosa*, *E. faecalis*, and *S. aureus*, among others, which decreases the occurrence of secondary caries.

Biomaterials in caries prevention and treatment [42]:

- Recently, some novel biomaterials have been developed in caries prevention and treatment.
- Nanoparticles of amorphous calcium phosphate (NACP) and CaF₂

- PAMAM - 9 Poly (Amido Amine)
- Quaternary ammonium methacrylate (QAMs).

Adhesive restorations

- Bonded amalgam restorations (Amalgam bond)
- Novel adhesive systems
- Compomers and giomers.

Resin infiltration [43]:

Resin infiltration is an advanced way of treating initial carious lesions that fits perfectly with minimal intervention dentistry. Infiltration of non-cavitated lesions of proximal and smooth surfaces of deciduous and permanent teeth is a non-invasive method of preserving tooth structure.

Figure 18: Resin infiltration and Minimal Intervention Dentistry.

Nanotechnology in paediatric dentistry [44]:

Nano dentistry will make possible the maintenance of comprehensive oral health care by employing nanomaterials, biotechnology, including tissue engineering and dental nanorobotics.

Fluoridated HA coated preformed metal crowns [45]:

Clark, *et al.* in 2013 developed a novel technology to manufacture Fluoridated HA crystals directly on preformed metal crowns so as to provide full coverage restorations with anti-cariogenicity benefiting caries susceptible paediatric and adult patients.

Figure 19: Fluoridated HA coated Preformed Metal crowns.

Tailor made dental recalls

AAPD Recall Guidelines [46]:

Risk Category	Diagnostics	Interventions			Restorative
		Fluoride	Dietary Counseling	Sealants	
Low risk	<ul style="list-style-type: none"> – Recall every six to 12 months – Radiographs every 12 to 24 months 	<ul style="list-style-type: none"> – Drink optimally fluoridated water – Twice daily brushing with fluoridated toothpaste 	Yes	Yes	– Surveillance
Moderate risk	<ul style="list-style-type: none"> – Recall every six months – Radiographs every six to 12 months 	<ul style="list-style-type: none"> – Drink optimally fluoridated water – Twice daily brushing with fluoridated toothpaste – Fluoride supplements – Professional topical treatment every six months 	Yes	Yes	<ul style="list-style-type: none"> – Active surveillance of non-cavitated (white spot) caries lesions – Restore of cavitated or enlarging caries lesions
High risk	<ul style="list-style-type: none"> – Recall every three months – Radiographs every six months 	<ul style="list-style-type: none"> – Drink optimally fluoridated water – Brushing with 0.5 percent fluoride gel/paste – Fluoride supplements – Professional topical treatment every three months – Silver diamine fluoride on cavitated lesions 	Yes	Yes	<ul style="list-style-type: none"> – Active surveillance of non-cavitated (white spot) caries lesions – Restore of cavitated or enlarging caries lesions

Figure 20: AAPD Recall Guidelines.

Dental recall (NICE guideline) [47]:

For practical reasons, patients should be assigned (at a particular point in time) a recall interval of 3, 6, 9 or 12 months if they are below 18 years of age, or 3, 6, 9, 12, 15, 18, 21 or 24 months if they are 18 years or over.

Conclusion

Now paediatric dentistry has a better understanding of prevention of dental diseases, with the advent of advanced restorative materials but still there is reluctance in a wide group of dentists to use these materials and techniques. The reasons can be cost of the equipment and the consumable materials which becomes a deciding factor for most practitioners. The future of remineralisation dentistry lies in the development of remineralising agents that have the capability to remineralise dentinal lesions as well as smart biomimetic materials to restore the lost tooth structure. As paediatric dentists practicing MIPD not only makes the treatment efficient but also makes behaviour management of the child much easier due to advance painless microinvasive and non-invasive techniques.

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