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Review Article

Restorative strategies for carious lesions in primary teeth-Past to Present: A Narrative Review

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ABSTRACT:
The insight into the biological aspects of caries process in conjunction and the advent of variety of materials have synchronously revamped the invasive management strategies for the carious primary teeth to minimally invasive options in past two decades. This article attempts to classify and explore the diverserestorative options described at variable times in literature. The primary focus is the strategies recommended for the management of asymptomatic cavitated lesions in vital deciduous molars. The outline of various proposed approacheswith their perspective mechanisms can assist in selecting and formulating appropriate treatment plans for the corresponding the established diagnosis.

Key words: Complete caries removal, selective caries removal, step-wise caries removal, SDF, Hall Technique, SMART Technique, SMART-Hall Technique, primary teeth.

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INTRODUCTION

Dental caries is the preventable but unfortunately most widespread chronic oral disease (WHO) that manifests in primary, mixed and permanent dentitions at various ages.[1]The global prevalence of childhood dental caries is estimated to be 46.2% in primary teeth.[2]The pooled prevalence of crown caries from India is recorded as high as 54 % and 58 % in the primary and mixed dentitionrespectively.[3]The disease exhibits variable severities and array of therapeutic options,from the simplest fluoride applications to complex crown reconstructions have been proposed for management. The anxiety levels, behavioral issues,limited life span, reduced autonomy and variable parental perceptions etc.confers for somewhat different treatment approach for pediatric patients. [4,5] The strategies to treat primary teeth have been advanced from surgical to biological methods with the aim to arrest or slow down the caries progression in such a way that tooth exfoliates asymptomatically on its own without causing any pain, infection or discomfort. As per author's primary search, the literature is lacking in compiled evolutionary evidence exclusive for the dentinal caries in deciduous teeth. Hence, this review aims to configurethe various proposed management approachesfor asymptomatic dentinal carious lesions (ICDAS –II, Code 4-6) in primary molars.

SEARCH STRATEGY

The PubMed, Google Scholar, Cochrane Library and grey literature was searched for the articles relevant to topic. The literature search reveals that the restorative management strategies for the carious asymptomatic vital primary teeth can broadly be categorized under surgical andbiological methods for caries treatment. The frame of reference from the perspective of caries prevention, caries arrest and damage reversal has also been illustrated. (Table-I)

1. Surgical Method/Complete Caries Removal (CCR)

Also known as conventional restorative or surgical approach this traditional method is a "damage replacement", "drill and fill", method that excised carious dentine completely, established tooth preparations and rebuilt the teeth to their original form and function by the restorative materials. It does not

take charge of the actual etiology, progress and propagation of the disease process. The procedure itself is invasive and involves use of local anesthesia, high –speed rotary instruments and demands adequate isolation. The approach is arduous and challenging in pediatric cases than less invasive procedures.[6-8]The procedure can be accomplished by following ways:

Extension for Prevention:
The complete caries removal as mentioned above is accompanied by theinclusion of susceptible pits and fissures in the preparation and restoration with amalgam. The practice has been discontinued in the present era.

Conservative Adhesive Restorations (CAR):
Previously known as Preventive Resin restoration, CAR was first described by Simonsen and Stallard in 1977 [9] and further refined in 1985.[10] It is a conservative reply to 'extension for prevention' philosophy. The procedure involves generalized four steps i.e. anesthesiaand isolation, tooth preparation, adhesive restoration and sealant application. Specifically Type C-CAR areindicated for the dentinal lesions with the aim of integrating therapeutic damage replacement (by composite) with the preventive occlusal sealant for the incipient caries on the same occlusal surface.[11] The pulp protection using calcium hydroxide liner and GIC is indicated for lesions near to pulp.Although permissible in primary teeth, this modality has been widely studied for permanent molars in young children.

Biological Restoration
Despite of the name 'biological restoration', the technique utilizes the surgical approach concentrating on complete caries removal for the extensively decayed teeth or in rampant caries under local anesthesia and isolation. The impression is made and any autogenous extracted/exfoliated tooth or one received from tooth bank as per availability is contoured according to the coronal dimensions of decayed one. It is autoclaved at $121^{O}C$ for 20 minutes and ultimately adhesively bonded to the prepared tooth as biological restoration.[12]Being investigated for a decade, this concept has stalled in current practice.[13]

2. Biological methods
The biological approach discords the surgical model by incorporating less or minimally invasive techniques that focus on biofilm alteration to arrest or slow the decay progression, instead of completely removing it.[14,15]Both the approaches have been reported to have similar clinical, radiographic and final outcomes irrespective of age, gender, tooth type and number of involved carious surfaces in the primary dentition. [16]The biological approaches are more cost –effective and achieve more patient acceptance compared to the conventional ones.[17] The various biological approaches are discussed as follows:

Atraumatic Restorative Technique (ART)
Pioneered in the mid-1980s by Jo Frencken from Tanzania, ART is a minimal intervention, primarily damage replacement approach that aims to remove maximum decayed tissue using hand instruments without local anesthesia. The preparation was ultimately restored with an adhesive restorative material. The simple no drill procedure removed the sensory triggers, reduced dental anxiety and discomfort amongst the children. It has also been an added advantage for providing basic care to remote areas with limited resources outside the dental office. Glass ionomer cements, resin-modified glass-ionomer cement (RM-GICs), composite resins, and compomers have been the suggested adhesive restorative materials for the technique. Currently, high viscosity GIC and RM-GIC's are the most recognized materials due to their chemical sealing, durability, ease of use andfluoride –releasing anti-cariogenic activity that supplements damage reversal with caries arrest.[18]Higherrisk of restoration failure in H-GIC ART compared to conventional treatment has been reported for the caries lesions in primary teeth.[19] ART is being disregarded as a definitive procedure due to absence of follow-up care in community settings. Owing to variable therapeutic goals,AAPD(2008) added the term interim therapeutic restorative technique (ITR) for theprocedure used in contemporary dental practice.
"Modified atraumatic restorative treatment" has been proposed by Massara et. al. that suggested the removal of enamel caries with rotary handpiece and dentinal decay by hand instruments.[20]

Partial Caries Removal (PCR)
A Cochrane systematic review recommends the partial caries removal can be performed by two techniques i.e.

Step-wise caries removal (SWR)
It is a two step conservative approach. At first visit, a temporary restoration with calcium hydroxide liner is placed after selective removal of bulk of carious lesion to soft dentine. The liner is expected to remineralize/arrestThe second visit scheduled after 6-12 months[21]re-enters the tooth by removing the temporary restoration for caries excavation to firm dentin followed by placement of permanent restoration as the replacement of lost tooth structure.[22] The need of re-entry in a clinical and radio graphically arrested lesion, and risk of loss of temporary restoration are the controversial aspects for this technique.[23]

Selective caries Removal (SCR)
It is a single-step procedure that removes the decay to the firm dentin in the peripheral walls and to the soft

but still currettable dentine by the excavators towards the pulpal wall along with the placement of definite restoration at same visit. Partial caries removal in primary teeth significantly reduces the risk of pulp exposure than CCR with slightly increased reduction in SCR as compared to SWR. [24-26] The odds of failure of composite restorations were higher in SCR than CCR in intention-to-treat analysis. [26]

Sealing on carious Tissue (SoCT) without Caries Removal

The effect of restoration of dentinal caries with different sealing materials without the removal of decay has been studied with variable results. Hesse D et al. had recorded the equal efficacy but higher re-application frequency of applied resin pit and fissure sealants without caries removal in comparison to the partial excavation in occlusal cavities reaching outer half of dentin at 18 months follow-up.[27]Similar results have been reported with Zinc reinforced GIC at 1 year.[28] Higher longevity has been documented with flowable composites and RMGIC's at 2-year follow up. [29,30]

Non-Restorative cavity control (NRCC)

It is a three part treatment optionfor cavitated dentinal /enamel lesions of primary teeth –that combines Non-Operative Caries Treatment Program (NOCTP) for enamel and Non-restorative cavity treatment (NRCT) for dentinal lesions.[31] The first step trains the patient/parent for the diet modifications andimproved oral hygiene measures like regular tooth-brushing with fluoride toothpaste. The second stepaccomplishes the lesion exposure by removing the overhanging enamel henceforth making it self-cleansable by increasing the tooth brush accessibility.The biannual application of 38% silver diamine fluoride (SDF) is recommended as third step due to superior chances of arresting advanced cavitated lesions compared to other proposed protocols.[32]

Silver Diamine Fluoride (SDF)

SDF is a topical colorless ammonia solution containing silver and fluoride ions studied at the variable concentrations of 8%, 10%, 12%, 30%, 38% and 40 % for caries remineralization.[33] Evidence proves the greater effectiveness of semiannual application of ADA/FDA approved 38% concentration that contains around 25% silver, 8% ammonia, and 5% fluoride with 44,800 ppm fluoride release.[34] It is colorless or tinted blue liquid, with alkaline pH of 10-13. It can be applied directly on the carious tooth structure according to manufacturer's instruction. Black staining creating aesthetic issues is the major concern that can be minimized by adequate isolation and eliminated by potassium iodide solution.[34]

3. Hall Technique

Introduced in 2006 by Dr. Norna Hall from Scotland, Hall technique is a biological method that straightforwardly cements preformed metal crowns (PMCs) with GIC on decayed primary molars without any local anesthesia, caries removal, or tooth preparation. The disruption of nutrients to micro-organisms and sealing of superficial plaque layer that is indispensable for caries progression changes the biofilm compositionhencefortharresting or at least slowing down the decay process in primary teeth.[35] Recent systematic reviews consider it as a promising option having high acceptability, longevity and low failure rate for managing carious primary molars when compared to conventional therapeutic modalities. [35,15]Modified Hall technique recommending the selective removal of soft dentine and placement of crowns without the use of separators has also been suggested. The seatedcrowns are finally adjusted with the proximal slicing for improved marginal seal.[36]

Silver Modified Atraumatic Restorative Technique (SMART)

This novel approach integrates glass ionomer cement (GIC) restorations with silver diamine fluoride (SDF). The bactericidal SDF reacts with hydroxyapatite to form calcium fluoride in carious lesion. However it is unstable and has tendency to be washed with time thereby demanding multiple applications.[37]SMART seals the applied SDF with high viscosity chemically cured GIC to achieve the advantages of both SDF and ART for the superior results. The decayreorganization is achieved by the formation of caries resistant base by the reaction between odontoblastic calcium and phosphate ions with fluoride from SDFand strontium from GIC. Due to the meager fluoride release of GIC compared to SDF,it predominantly preventsthe biofilm retention and microbial proliferation by imparting a chemical seal that further disconnects the bacterial nutritional supply.[37,38] SMART has been found to be less time consuming with comparable clinical performance and survival as ART and CCR in deciduous molars. [39]

SDF –Hall/ SMART- Hall Technique

The placement of preformedstainless steel crowns after the SDF/SMART application with the aim of enhancing longevity is being recently investigated.Mittal M (2024) recorded similar outcomes in randomized controlled trial investigating SDF-HT compared to conventionaloperative procedures at 1-year follow-up.[40] Paranjape and Shah managed multiple carious primary molars after silver diamine fluoride (SDF) application and GIC restoration followed by placement of stainless steel crowns in 5-year old patient with acceptable results achieved after 1-week. [41] Further long term trials are going on for the more predictable results.

4. LASERS

Hard tissue lasers Er:YAG and Er,Cr:YSGG have proved to be effective for tooth preparation and decay removal in primary teeth with least impact on pulp and other soft tissues. Similar effectiveness to conventional methods with the advantages of minimal invasiveness, reduced pain and anxiety, and increased patient comfort, cooperation and acceptance has been demonstrated by them.[42,43] The lesion sterilization along with high level of decontamination can prevent or delay the caries recurrence. It can also be combined with SDF application for enhanced results. [43]

Table I- Outline of various management strategies of dentinal carious lesions in primary teeth

Technique	Recommended Restorative Material	Operating Principle
Surgical Methods		
CCR	Amalgam	Damage replacement
CCR with extension for prevention	Amalgam	Damage replacement, Prevention
CAR-Type C	Adhesive Resin with fissure sealant	Damage replacement, Prevention
Biological Restoration	Human tooth	Damage replacement
Biological Methods		
ART	High viscosity GIC and RM-GIC's	Damage replacement, caries-arrest
SWR	Liner-Calcium hydroxide Temporary restoration -GIC Permanent restoration-Adhesive resins	Damage Replacement, caries remineralization
SCR	Liner-Calcium hydroxide/bioceramic Permanent restoration-Adhesive resins	Damage Replacement, caries remineralization
SoCT	Pit and fissure sealants, GIC,RMGIC, adhesive resins	Damage Replacement, caries-arrest
NRCC	SDF, No restoration given	Prevention, biofilm inhibition,caries-arrest, caries remineralization
Hall Technique	SS crowns without any restoration	Biofilm inhibition
SMART	High viscosity GIC and RM-GIC's with SDF	Damage Replacement, biofilm inhibition, caries-arrest, caries remineralization
SDF-HALL	SS crown with SDF	Damage Replacement, biofilm inhibition, caries-arrest, caries remineralization
SMART-HALL	SS crown with GIC and SDF	Damage Replacement, biofilm inhibition, caries-arrest, caries remineralization
LASERS	No restoration	Caries remineralization

5. CLINICAL PERSPECTIVE

Depending upon the three main factors i.e. the activity, cavity and cleansability dental carious lesions can broadly be intervened by non-invasive, micro-invasive, invasive and mixed methods. [44] The therapeutic aim for primary molars is asymptomatic, uninfected functional retention,till or near the time of exfoliation.The variable anatomical and histological characteristics increase the chances of pulp exposure with conventional methods and hence are rarely indicated nowdays. ICDAS score, remaining tooth structure, age and cooperative ability of child are the concerned factors determining the intervention in younger children. The step-wise approach commencing with risk assessment, plaque control, caries remineralization/ caries arrest and achieving adequate seal with coherent behavior modification can be planned as applicable for specific pediatric patients.

CONCLUSION

The spectrum of approaches proposed for the treatment of dentinal lesions of primary teeth has shifted from the surgical to biological one in recent years. An adequate minimally invasive treatment plan can be formulated on the basis of the patient's age, anxiety level, behavioral approach, and extent of caries, remaining tooth structure and pulpal status. Any selected approach should be integrated with adequate plaque control and reduction of risk factors for effectivelong-term outcomes.

Conflict of Interest: The authors declare no conflicts of interest.

Author Contribution: AK and IPK contributed in conceptualization and literature search. IPK defined the content, designed and prepared the manuscript. AK reviewed and edited manuscript. Both the authors agreed to the final version before submission.

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