

Contemporary strategies and concepts of caries removal techniques - A literature review

¹Dr. Anu V F, Post graduate student, Department of Pediatric and Preventive dentistry, Government Dental College And Research Institute, Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India.

²Dr. Nagarathna J, Associate Professor and Guide, Department of Pediatric and Preventive dentistry, Government Dental College And Research Institute, Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India

³Dr. S K Srinath, Professor and Head of Department, Department of Pediatric And Preventive Dentistry, Government Dental College And Research Institute, Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India.

Corresponding Author: Dr. Anu V F, Post graduate student, Department of Pediatric and Preventive dentistry, Government Dental College And Research Institute, Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India.

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Abstract

The concept of caries being an infectious disease in the light of specific plaque hypothesis are bygone. The advent of ecological plaque hypothesis brought about a radical change in all realms of science involving caries diagnosis and management. Over the century, augmentation in technological advancement coupled with newer biomedical devices has aided and abetted dentistry in delivering treatment of superior quality supported by better understanding of the disease. Although caries is an age-old disease, the way it is managed has undergone marked transformation. Traditional methods of caries excavation, based on the principles of complete removal often resulted in grave repercussions of pulpal health. Recent consensus papers conclude that bacterially contaminated and or

demineralised tissues close to the pulp can be preserved. Conservative approaches in order to maintain pulp vitality and homing the treatment on biological basis should be the prime concern in managing carious lesion. **Keywords:** caries removal, stepwise excavation, selective caries removal.

Introduction

Management of deep carious lesion should follow a conservative approach in order to maintain pulp vitality and home the treatment on biological basis. This can be accomplished in radiographically deep caries and asymptomatic or mildly symptomatic teeth by selective removal of caries and restoration in one or two visits. On the other hand, non-selective caries removal strategies emanate a sequelae of frequent pulp exposure,

unsuccessful invasive and expensive outcomes that can backlash on the long-term longevity of the tooth.

“Death spiral of restorations” refers to the process of recurrent and elevated re-interventions on dental restorations.

Avoiding entry into this spiral and stretching it over a patient’s lifetime should be the primary concern in treating the child patient. ⁽¹⁾

Morphological and histological differences along with a limited life span affects the caries removal strategies in primary teeth. Thinner dentin with large diameter, low density tubules and a lower proportion of S-shaped tubule contribute to faster progression of caries ⁽²⁾

Caries excavation should ultimately result in creating conditions for a long-lasting restoration, preserving healthy remineralizable tissue, obtaining sufficient seal and maintaining pulpal health, escalating the success of the restoration. ⁽³⁾

Main Text

Insight into the carious process

Currently, caries is defined as “a biofilm-mediated, diet modulated, multifactorial, non-communicable, dynamic disease leading to net mineral loss of dental hard tissues” ⁽³⁾

Caries lesion is the clinical sign of caries and can be identified at various detection thresholds and stages, e.g., non-cavitated, micro-cavitated, and cavitated, clinically or via supplemental methods like radiography, optical or electrical means. Surface characteristics such as change of texture, translucency, and colour defines the activity status. ⁽⁴⁾

An actively progressing carious dentine lesion is easy to disintegrate/penetrate the soft organic matrix with a dental probe, tends to have a light yellow/ beige colour and a wet/moist surface texture. A less active lesion is

dry and firmer when probed, tends to be darker with a colour closer to brown.

An arrested /inactive lesion is darker, without excess moisture, and impenetrable to probe ⁽⁵⁾

Cariou lesion severity can be assessed by staging the progress of net mineral loss either clinically or radiographically. ⁽⁴⁾

Radiographically, those involving the inner third or quarter of dentine or with clinically assessed risk of pulpal exposure are referred to as Deep carious lesions ⁽⁵⁾

Based on dental practitioners’ expectations, deep stage caries can be classified as ‘Deep’ carious dentine lesion when a well-defined zone of dentin separates pulp from the demineralized dentin and Extremely deep lesions when this zone is absent and the critical zone of tertiary dentin and pulp are accessible to the microbiota. ⁽⁵⁾

Dentin – the helm of caries excavation

The limits of caries excavation are dependent on the quality of dentin. Thus, it is crucial to know its characteristics and classify dentin.

The outstanding work of Takao Fusayama, published in 1980, identifies two layers in caries lesion. The “outer carious dentin”, highly demineralized and infected layer with loss of collagen cross linkages and the hydrodynamic system of dentinal tubules making it incapable of remineralization. ⁽⁶⁾ The consistency can be compared to cottage cheese. ⁽⁷⁾

The “inner carious dentin”, partially demineralized and slightly infected layer retained their structural integrity of collagen network and dentinal tubules and was sensitive to removal. The enlarged lumens of this layer contain whitlockite crystallized into the dentinal which could be restored to normal with pH neutralization. ⁽⁶⁾

The consistency may be referred to as leatherlike. ⁽⁷⁾ Tubular sclerosis, a gradual mineralisation of the tubule lumens which can lead to complete obstruction of the

tubules is the most common observed defense reaction to caries.⁽⁸⁾

Histopathological interpretation of clinical manifestations aid in accurate excavation.⁽⁹⁾

A recent consensus recommendation, by Innes et al in 2016 has related clinical (tactile) manifestations to histological terms.⁽¹⁰⁾

Caries endpoint determination

There has been an increasing surge in developing new concepts or criterions in assessing caries removal. Furthermore, removal methods such as self-limiting burs and chemo mechanical removal that aid in achieving this are gaining in popularity.^(4,11)

Texture

Hardness of the dentin, a vital factor determining caries removal strategies, can be identified at various thresholds:

Soft Dentine

Allows easy excavation and deforms when a hard instrument is pressed over.

Leathery Dentine

Transition between soft and firm. Does not deform with instrumentation but can be easily lifted with little force.

Firm Dentine

Physical resistance to hand excavation is seen which requires some pressure in order to be lifted.

Hard Dentine

More resistance requiring a sharp instrument or bur to lift it pushing force is needed for hand instrument to engage it. "Cri dentin Aire" is noted on probing across the dentin.⁽¹⁰⁾

Colored solutions

Subjective variability, added with anatomical softening of reparative dentin outdated the use of texture alone as the criteria for caries excavation. With the advent of propylene glycol-based dye, an adjunct to this task was

introduced. The outer carious dentin stained dark red and the inner carious dentin light pink. The interphase, referred to as turbid dentin contains a mixture of parallel groups of tubules. Deeper to turbid layer, a lighter staining (pink haze) transparent zone is present which is translucent in histologic sections. Crystals of whitlockite in the tubules limits its permeability to bacterial invasion as well as pulpal fluid transudation. Deeper to this, a layer an interphase of transparent and healthy dentin termed sub transparent zone is present. This allows adequate excavation and prevents over excavation.

Periodontal probes

Periodontal probes can be utilized in order to avoid pulp exposures. If excavation involves intermediate dentin, 3-4 mm from occlusal aspect, the red staining infected dentin can be removed to light pink staining caries end points. On the other hand, deeper lesions extending > 5mm from occlusal or > 3mm from DEJ excavation should be halted disregarding the red staining dentin

Diagnodent

The creation of a peripheral seal zone of approximately 1-3 mm wide consisting of healthy superficial dentin and enamel with a DIAGNO dent value of 12 or total absence of caries detecting dye would aid in better prognosis. Pulp exposures can be avoided by leaving the partially demineralized dentin with a value of 20-24 for intermediate dentin and 36 for deep dentin.⁽⁶⁾

Face (fluorescence aided caries excavation)

The principle of tissue autofluorescence can be utilized with strong green autofluorescence for uncontaminated and red autofluorescence of the contaminated dentin emanated by porphyrins.⁽¹⁾

Principles for caries excavation

Removal of Carious Tissues -To avoid the synonymous link with hand excavation instrumentation and spoon

excavators, the term removal is preferred over excavation.⁽⁵⁾

The guiding principles in the removal of carious tissue are

- Non-demineralized and remineralizable tissue is to be preserved.
- achieve an adequate seal by seating the peripheral restoration onto sound dentine and/or enamel, thus controlling the lesion and inactivating remaining microflora
- Using methods which do not evoke discomfort/pain and dental anxiety
- preserve residual dentine and prevent pulp exposure and thus maintain pulpal health⁽¹⁰⁾

Management strategies ensuing caries excavation

The excavation of carious tissue is highly dependent on the management strategies to be followed

1. Atraumatic restorative treatment

Carious lesion management using hand instruments alone. Selective removal of carious tissue to firm texture or hard is decided depending on cavity depth in order to avoid pulp exposure.

2. No removal

Although no tissue is removed, these procedures aid in controlling the disease process and include Sealing techniques (Resin or GIC sealants), Hall technique (sealing with preformed crowns) and Nonrestorative cavity control (NRCC) *(prevents further loss of tooth structure by making them more cleansable.*⁽¹⁰⁾ Existing lesions in primary dentition can be transformed into cleansable lesions and managed^(12,13))

3. Removal Strategies for Deep Lesions with sensible pulps

They are mainly four in number:⁽¹⁾

3. a) non-selective removal to hard dentin

Formerly termed 'complete removal' was based on the criteria of texture alone. Involves removal of all the softened tissue till hard dentin is reached and was not focused on biologically based approaches that aimed at preserving pulp vitality. In any event of pulp exposure, root canal therapy was ensued. This is has been the traditional approach practiced and needs reconsideration in the light of new evidences supporting that leaving a small amount of soft dentin is beneficial for the long term viability of the tooth structure.^(5,10,14)

This rethinking is based on ecological plaque hypothesis and extended ecological caries hypothesis. Thus, instead of removal, the focus should be on shifting the ecological and metabolic balance into a one promoting remineralization and thus arrest of the disease process.⁽¹⁵⁾

3.b) selective removal to firm dentin

This approach is used for moderate or shallow lesions where sound enamel or hard dentin can be found at the periphery of the cavity and does not extend to the inner one third or quarter of dentin.⁽¹⁰⁾

3.c) selective removal to soft dentin

For vital asymptomatic deep carious lesions, maintenance of the remaining dentin thickness is the prime objective in order to avoid pulp exposure. The various criterions mentioned above are effectively used here.⁽¹⁰⁾

Numerous techniques are available in this regard. Some claim to be selective but most are non-selective and depends on clinician's discernibility.

- Among conventional burs, a round bur is preferred. With regard to invasiveness, bur prepared cavities tend to over excavate.^(16,17)

- Low speed (PEKK – polyether-ketone-ketone) polymer burs possess intermediate hardness, between carious and sound dentin and tend to bend if attempted

to remove harder dentin and can be used to selectively remove caries. ⁽¹⁷⁾

- “Bio-bur” -Impregnation of burs with ions/ particles is under research. ⁽¹⁾
- The CeraBurs (alumina-yttria stabilized zirconia) - claimed to provide tactile sensation and can evidently reduce preparation time.
- **Ultrasonic and sonic instrumentation** chips away hard dental tissues using the principle of probe tip oscillation and irrigant micro-cavitation. ⁽¹⁾
- **Sono-abrasion**- A novel technology using high-frequency, sonic, air-scalers with modified abrasive tips. ⁽¹⁷⁾
- **Air Abrasion**- commercially available bioactive glass powder (Bio glass 45S5, Syc TM) capable of

exhibiting an intrinsic selectivity towards carious demineralised enamel are now available. ⁽¹⁾

- **Chemo mechanical preparation**- Greater tactile sensitivity is offered by Hypochlorite/amino acid-based gel system (Cari Solv) when used with special non-cutting hand instruments permitting selective dentin removal ⁽¹⁾⁽¹⁶⁾
- **Lasers**- The Er: YAG and Er, Cr: YSGG lasers are used in this aspect. ⁽¹⁸⁾

3.d) stepwise removal

Stepwise excavation essentially involves two steps. In the first visit, selective removal to soft dentin is done and in the second visit, about 6 months to a year later, it is extended to firm dentin. ⁽¹⁾ Successful stepwise removal in adults in well-defined (not extremely) deep carious lesions is supported by robust evidence ^(19 - 22)

Table: Literature evidences

Author	Title	Conclusions
Cochrane Systematic Review		
Ricketts D, Lamont T, Innes NP et al ⁽²⁴⁾ 2013	Operative caries management in adults and children.	SWR and SLR reduced incidence of pulp exposure
Systematic Review & Meta analysis		
Schwendicke F, Dörfer CE, Paris S. ⁽¹⁵⁾ 2013	Incomplete caries removal: a systematic review and meta-analysis.	Incomplete caries removal reduces risk of pulp exposure.
Tedesco TK, Reis TM, Mello-Moura AC et al ⁽²⁵⁾ 2020	Management of deep caries lesions with or without pulp involvement in primary teeth: a systematic review and network meta-analysis.	Best ranked success rate for hall technique in deep lesions.
Schwendicke F, Paris S, Tu YK ⁽²⁶⁾ 2015	Effects of using different criteria for caries removal: a systematic review and network meta-analysis	Data regarding self-limiting excavation is inconclusive.
Randomized Controlled Trials & Clinical Trials		
Banerjee A, Kidd EA, Watson TF ⁽²⁷⁾ 2003	In vitro evaluation of five alternative methods of carious dentine excavation.	Superiority of conventional hand excavation.

Bjørndal L, Reit C, Bruun G et al ⁽¹⁹⁾ 2010	Treatment of deep caries lesions in adults: randomized clinical trials comparing stepwise vs. direct complete excavation, and direct pulp capping vs. partial pulpotomy.	Stepwise excavation significantly reduces pulp exposure
Maltz M, Garcia R, Jardim JJ et al ⁽²⁰⁾ 2012	Randomized trial of partial vs. stepwise caries removal: 3-year follow-up.	Partial caries removal had better survival rates than stepwise removal.
Franzon R, Guimarães LF, Magalhães CE et al ⁽²¹⁾ 2014	Outcomes of one-step incomplete and complete excavation in primary teeth: a 24-month randomized controlled trial.	Partial caries removal was a reliable method and pulp vitality did not affect retention of restoration
Franzon R, Opdam NJ, Guimarães LF et al ⁽²²⁾ 2015	Randomized controlled clinical trial of 24-month survival of composite resin restorations after one-step incomplete and complete excavation on primary teeth	PCR requires constant follow up especially in case of multi surface restorations.
Bjørndal L, Fransson H, Bruun G et al ⁽²⁸⁾ 2017	Randomized clinical trials on deep carious lesions: 5-year follow-up.	Stepwise removal was more successful
Elhennawy K, Finke C, Paris S ⁽²⁹⁾ 2018	Selective vs stepwise removal of deep carious lesions in primary molars: 12-months results of a randomized controlled pilot trial.	SWR treatment costs were more than selective removal
Bakhshandeh A, Qvist V, Ekstrand KR. ⁽³⁰⁾ 2012	Sealing occlusal caries lesions in adults referred for restorative treatment: 2–3 years of follow-up.	Occlusal lesions can be effectively managed by resin sealants
Innes NP, Evans DJ, Stirrups DR ⁽³¹⁾ 2011	Sealing caries in primary molars: randomized control trial, 5-year results.	Sealing by hall technique outperformed conventional restorations
Innes NP, Evans DJ, Stirrups DR ⁽³²⁾ 2007	The Hall Technique; a randomized controlled clinical trial of a novel method of managing carious primary molars in general dental practice: acceptability of the technique and outcomes at 23 months	Hall technique was preferred by children, carers and practitioners
Boyd DH, Page LF, Thomson WM ⁽³³⁾ 2018	The Hall Technique and conventional restorative treatment in New Zealand children's primary oral health care—clinical outcomes at two years.	Hall technique showed better success over plastic restorations in deep lesions

Conclusion

The practice of evidence- based dentistry paves way to long term success rates of therapeutic management of carious lesions. In the light of conservative management techniques gaining literature support at a faster pace, traditional techniques of complete removal can be weaned off from paediatric dental practice.

Selective removal and stepwise removal followed by placement of restorations with adequate seal is the line of treatment currently supported. No removal, sealing and Hall technique are gaining popularity due to the increased patient acceptability, the ease of procedure as well as the higher clinical success rate. Novel techniques are highly researched in this field. More studies should be carried out to validate their efficacy, cost effectiveness and acceptability.

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