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Minimal Invasive Potential of Three Caries Excavation Methods in Children

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ABSTRACT

Background: Recently, the concept of minimally invasive (MI) dentistry has emerged. MI calls for the selective removal of heavily infected and irreversibly denatured dentin caused by carious lesions while preserving dentin that is demineralized but not infected. **Aim:** To compare the minimal invasive potential (MIP) of conventional caries excavation (CCE), caries detection dye (CDD), and fluorescence aided caries excavation (FACE) methods in children. **Subjects and Methods:** A total of 105 carious primary molars in 43 children were included in this study. The teeth were randomly divided into three groups according to the caries excavation method. Preoperative evaluation of the carious teeth was performed using digital radiography after sealing the cavities with a radiopaque material. Caries excavation was performed using CCE, CDD, or FACE method. The teeth were restored using self-cured glass ionomer. Post-operative radiographic examination was then performed. Pre-operative and post-operative widths and depths for the cavities were assessed. MIP was determined by comparing the prepared-cavity width and depth relative to the initial width and depth of the caries lesion, respectively. **Results:** There was no statistically significant difference between the MIP of examined groups neither after comparing cavity widths at p=0.253 nor depths at p=0.06. FACE showed the highest mean values of MIP potential for cavity widths (1.41±0.36) and depths (2.04±0.74). **Conclusions:** CCE, CDD, and FACE showed comparable MIP in children.

Keywords: Minimal invasive; Caries detection dye; Fluorescence

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Introduction

Recently, the concept of minimally invasive dentistry has emerged. Minimally invasive dentistry adopts a philosophy that integrates prevention, remineralization, and minimal intervention for the placement, and replacement of restorations [1, 2, 3]. This concept does not only eliminate the pain associated with the removal of caries but also instills a positive attitude in children towards dentistry [4, 5, 6].

Minimal intervention calls for the selective removal of infected, and irreversibly denatured dentin while preserving dentin that is demineralized but not infected, thus the treatment objective is achieved using the least invasive approach with the removal of the minimal amount of healthy tissues [3, 7, 8].

Caries excavation in primary teeth is a very critical process where the possibility of inadvertently causing pulp exposure by over-excavation is greater than in permanent teeth. This is due to the thinner enamel and dentin caps, and relatively more prominent pulp horns in primary teeth. Therefore, an accurate method for identification and removal of the infected layer of dentin in primary teeth would be very desirable [9, 10].

There are numerous caries excavation methods, and aids to caries excavation available to dentists today. These include conventional mechanical caries removal, chemomechanical agents, caries disclosing dyes, air abrasion, lasers, and fluorescence aided caries excavation [11, 12].

Conventional caries excavation involves the use of hand or rotary instruments in caries removal. Clinicians commonly excavate till reaching the firm dentin, and rarely consider whether demineralized dentin could be preserved and might have the potential for remineralization (8). The excavation end point is determined by the color and hardness of the tissue using visual and tactile criteria. This method is, however, highly subjective [8, 13].

Caries detection dyes are beneficial in early detection of incipient caries in pits, fissures, and smooth surfaces moreover they can be used as an adjunctive aid for identification of secondary caries around restorations and for examination of fissures for micro-fractures. The dye fills the voids created in enamel and dentin by acid attack, or the voids present in hypomineralized enamel [9, 14]. However, there are some concerns with the usage of caries detector dye, like inadvertent cutting of sound dentin, and increased time required for excavation [13].

Fluorescence has also been used to guide the caries excavation process, it aids in caries detection, and decision making during cavity preparation[13] Fluorescence aided caries excavation uses orange-red autofluorescence as a marker for infected dentin. It provides a clinical aid in the detection of infected hard dental tissues, particularly infected dentin [15]. This allows selective removal of infected dentin and preservation of non-infected tissues [8].

Thus, this study was conducted to compare the minimal invasive potential (MIP) of conventional caries excavation (CCE), caries detection dye (CDD) and fluorescence aided caries excavation (FACE) methods in children.

Subjects and Methods

This randomized controlled trial study was carried out in Pediatric Dentistry and Dental Public Health, and Oral Radiology Departments, in authors' institution to compare the minimal invasive potential (MIP) of conventional caries excavation(CCE), caries detection dye (CDD), and fluorescence aided caries excavation (FACE) methods in children. The ethical clearance for this study was obtained from research ethics committee of authors' institution. Children were selected according to the eligibility criteria and included in the study only after obtaining a written informed consent from their parents/caregivers. The study purpose, objectives and operative procedures were explained to the parents/care givers before obtaining the consent.

Inclusion criteria of the study included systemically healthy children aged between five –nine years having occlusal surface carious lesions in primary molars. The carious lesions extended till the dentin level, without extensive coronal destruction (intra-oral radiographs were taken to verify the caries involvement). While the exclusion criteria were children having incipient carious lesions in the enamel or extensive deep lesions close to the pulp, primary molars with clinical or radiographic signs and symptoms of irreversible pulpitis, radicular resorption involving more than half the root length, developmental defects, presence of abscess or fistula in relation to the teeth selected for the study, children having carious lesion on any surface other than occlusal surfaces of the selected teeth, or children with systemic illness that could compromise the conduct of the study.

The study sample consisted of 105 carious primary molars in 43 children (21 boys and 22 girls) with age range five to nine years with average 6.7 years. The teeth were randomly divided into three groups according to the caries excavation method using Sealed, opaque envelopes: Group 1: The caries was removed using a bur aided by a sharp dental explorer; the caries removal endpoint was reached when a hard cavity floor was felt upon gentle pressure with the dental explorer. Group 2: The caries was removed by a bur aided by caries detection dye; the caries removal endpoint was reached no caries detector stain remained in the cavity. Group 3: The caries was removed using a bur aided by red fluorescence marker; the caries removal endpoint was reached when no red-orange fluorescence could be seen.

In all groups, gaining access to caries was done using a diamond bur (Soco CO, LTD, Hong kong) in a high speed hand piece (Foshan Coxo Medical Instrument Co., Ltd, China) under continuous water-cooling, then carious dentin was removed using a stainless steel round bur (Soco CO, LTD, Hong kong) in a slow speed hand piece (Foshan Coxo Medical Instrument Co., Ltd, China).

Conventional Caries Excavation Group (CCE): Stained and softened dentin detected using a sharp explorer was removed, while stained hard dentin was left. The operating field was illuminated using a standard dental unit light.

Caries Detection Dye Group (CDD): Gross caries was removed. The teeth were dried briefly using compressed air. Caries detection dye (Seek® Caries Indicator, Ultradent Products, USA) was applied to the cavity for 10 seconds and the cavity was then rinsed with water for 10 seconds and dried using compressed air. The dentin which retained stain was selectively removed. This process was repeated until no caries detector stain remained in the cavity.

Fluorescence Aided Caries Excavation Group (FACE): The teeth were illuminated with violet light (380-420 nm) using a 40-280 mw Xenon discharge lamp (Foshan Coxo Medical Instrument Co., Ltd, China). Sound dental hard tissue fluoresces green and carious dental hard tissue fluoresces orange-red. The operator inspected the cavity through a 500 nm yellow glass filter (Foshan Coxo Medical Instrument Co., Ltd, China) and selectively removed the orange-red fluorescing areas whereas green fluorescing areas were conserved. The dental unit light was on but directed away from the operating field. After complete caries removal, the prepared cavities were restored using self-cured glass ionomer restorative material (Riva Self Cure, Glass Ionomer Restorative Material, Australia).

Pre-operative and post-operative standardized radiographic examinations were performed to evaluate initial and prepared cavity width and depth. Individually customized radiographic wax stent as well as paralleling technique with extension cone paralleling (XCP) film holder for posterior teeth were used to obtain reproducible images. Radiographic projection was taken by intra-oral X-ray machine (Minary, Soredex, Tuusula-Finland) with the following exposure parameters: 70 kVp, 7 mA, 0.08 sec exposure time, 30 cm focal film distance. Direct digital intra-oral radiographic system (Digora Optime, Soredex, Tuusula – Finland) was used with photostimulable phosphor (PSP) imaging plate size 0 as image receptor. All radiographic images were assessed blindly by a single oral radiologist - of more than 12-year experience inside a quiet room with dimmed light using the Digora for Windows 2.7 software on an 18.5-inch monitor (SyncMaster B1930N, Samsung, Seoul, South Korea) with a resolution of 1366×768. All images were evaluated with the same degree of magnification (×2). Brightness and contrast of the images were adjusted to obtain the best delineation of the restorations. Each image was assessed twice with a period of two weeks between the two sessions.

Prior to the preoperative radiographic examination, the teeth were sealed with zinc oxide and eugenol cement as a radiopaque material (Zinc oxide powder: A-Dent Company, Egypt; Eugenol liquid: GAMA Dent Company, Egypt) to reveal the cavity margins. Linear measurement of initial caries width was performed through a line for the widest extension of the lesion parallel to the occlusal plane of the tooth, while initial caries depth was measured through a line extending from the occlusal surface of the tooth to the deepest point of the cavity perpendicular to the former line. After cavity preparation and tooth restoration, the prepared cavity width and depth were measured in the same way (Fig. 1).

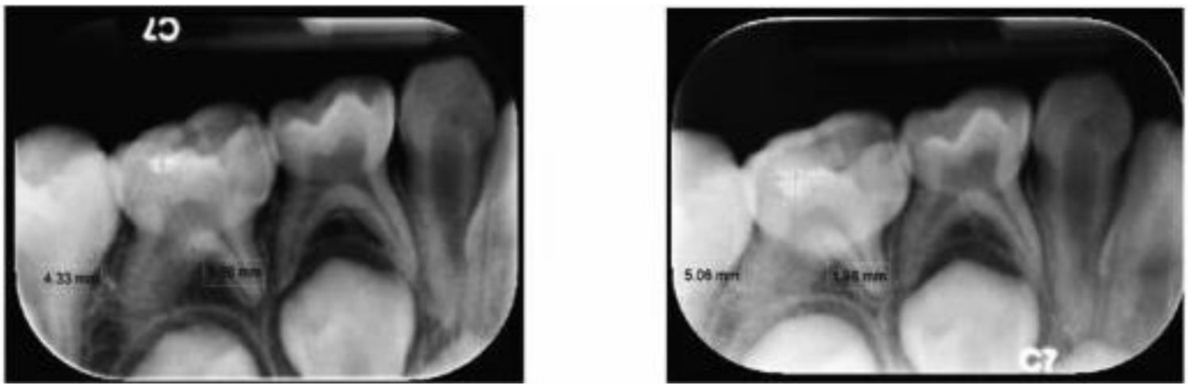

Figure (1): Radiographs showing pre-operative (left) and post-operative (right) measurements of cavity width and depth in tooth # 85.

The minimal invasive potential (MIP) of the different caries excavation methods was assessed by relative cavity width and depth which is the ratio of the prepared cavity width and depth to the initial caries width and depth respectively [16, 17].

Data were checked for normality using D'Agostino-Pearson test. Relative cavity widths and depths showed a nonparametric data distribution, thus, Kruskal Wallis test was used to compare between the three caries excavation methods. The level of significance was set at $p \leq 0.05$. All statistical analyses were performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows.

Results

his study was carried out on 105 primary molars; the minimal invasive potential of the three caries excavation methods was expressed in terms of relative cavity widths and depths. Data were statistically described in terms of mean and standard deviation. The results showed an insignificant difference between the minimal invasive potential of conventional caries excavation (CCE), caries detection dye (CDD), and fluorescence aided caries excavation (FACE).

The comparison of the relative cavity width of the three caries excavation methods revealed an insignificant difference between tested techniques at p=0.253. Fluorescence aided caries excavation showed the highest mean relative cavity width (1.41±0.36) followed by caries detection dye (1.33±0.26) while conventional caries excavation demonstrated the lowest mean relative cavity width (1.27±0.23) (Table 1 and Fig. 2).

By comparing the relative cavity depth of the three caries excavation techniques, fluorescence aided caries excavation also showed the highest mean relative cavity depth (2.04±0.74) followed by conventional caries excavation (1.81±0.69) while caries detection dye exhibited the lowest mean relative cavity depth (1.67±0.59) with a statistically insignificant difference between the caries excavation methods at p=0.06 (Table 1 and Fig. 2).

Table (1): Mean and standard deviation (SD) of relative cavity width and depth and *P*-value of the Kruskal Wallis test for the tested caries excavation methods.

	Caries Excavation Methods						p-value
	CCE		CDD		FACE		
	Mean	SD	Mean	SD	Mean	SD	
Relative cavity width	1.27	0.23	1.33	0.26	1.41	0.36	0.253 NS
Relative cavity depth	1.81	0.69	1.67	0.59	2.04	0.74	0.060 NS

NS=Non-significant

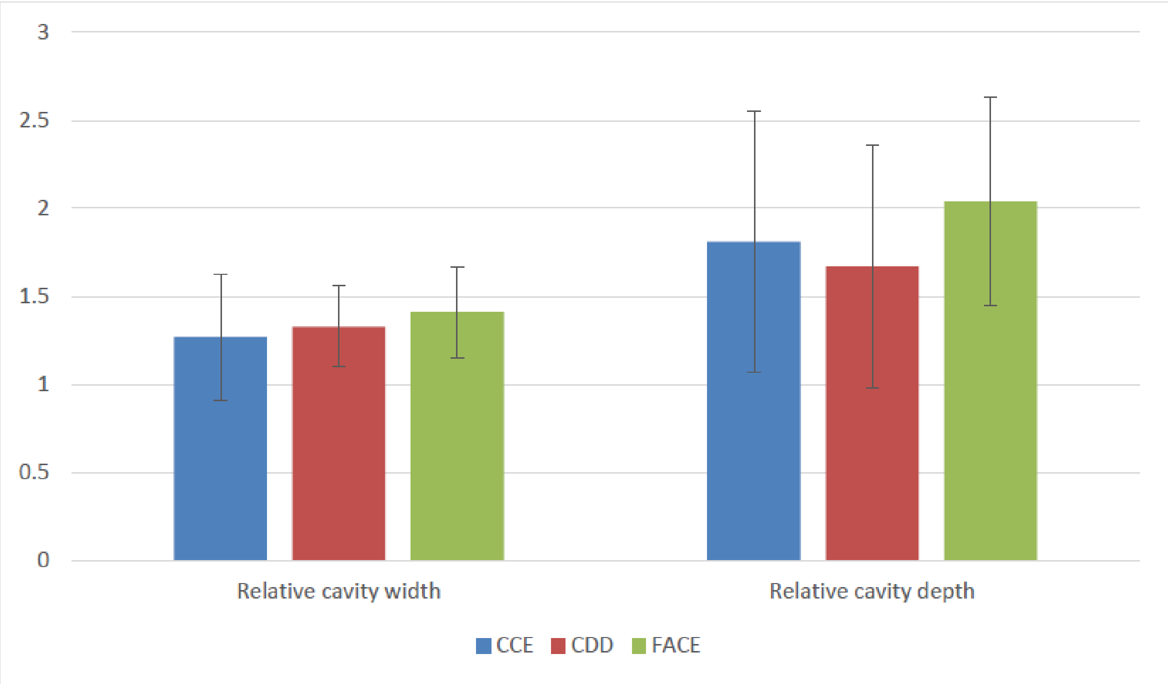

Figure (2): Bar chart showing the mean relative cavity width and depth for the three caries excavation methods.

Discussion

The ideal caries-excavation technique is the one that selectively removes the irreversibly destroyed tissue, but leaves the potentially remineralisable tissue at the cavity floor. Nevertheless, the exact endpoint of caries removal cannot be clinically easily defined. Thus, this study was conducted to compare the minimal invasive potential of conventional caries excavation, caries detection dye and fluorescence aided caries excavation methods in children [16].

In this study, all groups were excavated by three pediatric dentists, and all the radiographic images were assessed blindly by a single oral radiologist to alleviate bias and subjectivity in comparing the three caries excavation methods. Primary molars were selected to assess the caries excavation techniques rather than primary anterior teeth as primary molars serve in the child's oral cavity for longer period of time and are more prone for caries attack [4].

This study was performed on natural carious lesions in children, thus it was not possible to standardize all carious lesions exactly [18]. As a matter of fact, the initial caries dictates the prepared cavity size; therefore the mathematical difference between prepared cavity width and depth and initial caries width and depth respectively would not be valid for comparing the minimal invasive potential of the three caries excavation methods. Accordingly, the relative cavity width and depth (the ratio between prepared cavity and initial caries width and depth) were employed to provide a fair comparison among the three caries excavation techniques [8].

In conventional caries excavation group, caries removal endpoint was determined based on visual and tactile sensation criteria, these criteria were shown to be adequate to ensure removal of most of infected dentin [19].

The results of the present study showed that conventional caries excavation gave comparable results to the other two caries excavation techniques, this finding comes in accordance with Lennon et al [17] while contradicts the results of Zhang et al [8]. This contradiction may be related to the difference in the study design as the former study was conducted in vitro and on permanent teeth while this study was conducted in vivo and on primary teeth. Moreover, it was reported that dentists who are highly trained at the use of dental burs in slow speed or air turbine hand pieces, can practice minimally invasive dentistry effectively using them [20].

The minimal invasive potential of caries detection dye group was statistically insignificant when compared to the other caries excavation techniques. The most likely explanation for this result is that caries detection dye penetrated deeper into the primary teeth dentin due to increased porosity of primary teeth than permanent teeth, leading to over-excavation [9]. It was reported that caries detection dye tends to stain hypomineralized dentin, thus its use may lead to over-excavation in areas with lower mineralization, such as the dentino-enamel junction and circum-pulpal dentin and primary tooth dentin [16].

The fluorescence aided caries excavation technology uses the orange-red fluorescence as caries removal marker; this fluorescence is caused by porphyrins, which are by-products of the metabolism of oral microorganisms. Using porphyrins as a marker, the target is the bacterium [15]. Thus, it was found that the fluorescence aided caries excavation removes caries-affected tissue more than conventional caries excavation or caries detection dye [8], leading to complete removal of infected dentin which may compromise its minimal invasive potential due to over-excavation [9].

Conclusion

The use of caries detection dye, and fluorescence aided caries excavation showed minimal invasive potential in children comparable to conventional caries excavation. Clinical excellence and the objective of minimal intervention dentistry can be achieved by the appropriate use of any of the three caries excavation methods according to operator's preferences.

Conflict of interest:

The authors report no conflict of interest

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