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BIOLOGICAL EVALUATION OF PARTIAL CARIES REMOVAL IN CLASS II RESIN COMPOSITE RESTORATIONS WITH TWO DIFFERENT CLINICAL ENDPOINTS OF EXCAVATION: A 12-MONTH CLINICAL STUDY

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ABSTRACT

Background: Partial caries removal has received an increasing interest of dental clinicians and researchers with growing evidence of potential clinical effectiveness and long-term reliability.

Objective: This is a prospective clinical study into the biological reliability of partial caries excavation in class II resin composite restorations.

Materials and Methods: 40 patients with one deep class II lesion each have been recruited for the study (n=20). Class II cavities were prepared to produce sound enamel walls and hard dentin walls at cavity peripheries. Recruited subjects were classified into two groups according to the clinical end point of caries excavation. In group S, a layer of soft caries is left behind at the deepest part of the cavity while in group L, caries was excavated till leathery/firm dentin. A universal adhesive system was used employing the selective enamel etching strategy. A nanohybrid resin composite Neo Spectra ST was used to fill the cavities. Restored teeth were assessed at three week, three months, 6 months, and 12 months respectively for pulp vitality and post operative hypersensitivity. Chi-Square test was used for statistical analysis at a level of significance (P£ 0.05)

Results: None of the restored teeth showed signs of irreversible pulpitis or apical periodontitis at any study interval. There was insignificant difference between the test groups at three weeks, three months, six months, and 12 months respectively (P> 0.05).

Conclusion: Partial caries removal appears to be a clinically effective procedure that preserves pulp vitality in deep class II resin composite restorations.

KEYWORDS: Resin composite, Partial Caries removal, Endpoint of caries excavation.

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INTRODUCTION

Minimal intervention management of deep carious lesions has established a paradigm shift in the practice of restorative dentistry and enabled maintaining the biomechanical integrity of teeth as functioning units in the dental arch by saving pulp vitality and avoidance of pulp exposure in teeth with deep caries. [1] Complete excavation of carious dentin till hard dentin has been considered as an unnecessary, radical, and overzealous treatment that may sacrifice pulp vitality and eventually shortens the life span of the affected teeth. [2]

Partial caries removal is a one visit minimal intervention procedure used in carious lesions penetrating to the inner one third of dentin where pulp exposure is likely to take place when complete caries excavation is attempted. [2]

During cavity preparation, partial caries removal leaves behind a pulp-ward layer of infected dentin to avoid pulp exposure. Meanwhile surrounding walls of hard dentin and sound enamel in the preparation must be reached. This establishes a balance between confirming effective bonding to sound substrate tooth structure and reliable peripheral marginal and interfacial seal from one side and preservation of pulp vitality of the underneath healthy pulp on the other side. [3]

Partial caries removal makes use of cumulating evidence indicating that bacteria in the left infected dentin layer, when become deprived of essential nutrients by establishing a restoration with tight peripheral seal, they either die or remain inactive [4]. However, the long-term fate of residual caries in partial and stepwise caries removal is lacking. Moreover, there is no diagnostic technique to assess progress of residual caries. [3]

Two clinical endpoints have been reported for carious dentin excavation in partial caries removal. Excavation to leathery/firm dentin in moderately deep lesions not reaching the inner third of dentin and selective caries excavation to soft dentin where caries has extended to the deepest zone of dentin. Although using calcium hydroxide or glass ionomer liners have not found to influence the outcome of partial caries removal procedures, they can still provide an antibacterial effect.

While firm/leathery dentin has been described to be physically resistant to hand excavation, soft caries is cottage cheesy in texture, and is easily removed with hand excavators [3,4]

The literature shows inferior quality of resin bonding to carious dentin than to sound healthy dentin. Therefore, the success of partial caries removal procedure is based on effective bonding to sound peripheral dentin walls [5].

Universal adhesives are new group of one bottle resin adhesive systems that can be applied using the etch and rinse, the self- etch or the selective enamel etching approach. While etch and rinse approach is still considered as the gold standard adhesive bonding approach, selective enamel etching has been considered superior to self-etching approach when long term effectiveness of bonding is considered [6]. MDP containing bonding agents have been reported to enhance stability of the hybrid layer and long-term effectiveness of bonding to dentin with effective anti- matrix metalloproteinases effects [7].

Cervical margins of class II resin composite is a clinically challenging location particularly for establishing a long-term interfacial adaptation and effective marginal sealing quality. This is because of lack of adequate cervical enamel for effective bonding as well as the degradational influences of dental plaque biofilms and gingival fluid [8].

Berkowitz et al. reported that post restoration hypersensitivity has been defined as pain that takes place in association with mastication or with sensitivity to hot, cold, and sweet stimuli that occurs 1 week or more after restoration [9].

Therefore, this prospective clinical study has been designed to investigate the biological effectiveness of partial caries removal procedure employing two different clinical endpoints of

excavation, leathery/firm dentin or soft dentin using testing criteria of pulp vitality and post restoration hypersensitivity. The null hypothesis is that the clinical endpoint of excavation in partial caries removal does not influence pulp vitality and post-restoration hypersensitivity in managing deep class II caries.

MATERIALS AND METHODS

A total of 40 patients was recruited in this observational study (n=20). Ethical approval number 18-0014 was obtained from the ethical committee of the university. In each recruited patient one class II resin composite restoration was performed employing partial caries removal procedure. The included carious lesions were selected on basis of the American Dental Association system of classification of carious lesions. In the first group of 20 patients (L), one class II carious lesion extending not deeper to the middle third of dentin (D2) was selected. In the remaining 20 patients (S), one class II carious lesion extending to the inner one third of dentin (D3) was selected. The inclusion criteria involved patients with age group of 20-50 years old with no systematic debilitating disease and having good oral hygiene indicated by a healthy gingiva and a maximum of 4 carious teeth and regularly using toothbrush twice daily with [10] at least one deep class II caries evaluated using digital bite wing radiographs showing a proximal carious lesion of D2 or D3 score according to the American dental Association system of caries scoring. Moreover, all selected teeth showed normal periapical radiographs, normal response to percussion test and normal vital sensibility pulp response to cold thermal pulp testing using ethyl chloride spray [11,12] with no signs of reversible or irreversible pulpitis. Exclusion criteria involved patients with bad oral hygiene, parafunctional habits. Moreover, patients with dry mouth and poor dietary habits of consumption of carbohydrate snakes and those with dental plaque index of greater than 20% were excluded from the study.

The selected teeth had sound adjacent and opposing dentition. In line with several previous clinical studies, systematic caries risk assessment was not performed in this study [13].

Cavity preparation

After administration of local anesthesia, rubber dam isolation was performed. In each selected tooth, class II cavity were prepared using inverted cone and fissure carbide burs to include all the surface extension of carious lesion producing sound enamel walls and hard peripheral dentin walls. Cavities were prepared using ultrahigh speed range using air-water spray coolant. In the L group spoon excavators were used to excavate deeper dentin caries to an endpoint of leathery/firm dentin that shows resistance of removal by the excavator. In the S group, excavation was caried out to a deepest layer of soft dentin of cottage cheesy texture.

Restoration

A wedged sectional matrix was clamped to the respective tooth. 37% phosphoric acid etching was used to etch the prepared enamel cavity walls for 15 seconds followed by rinsing with water for 5 seconds and dryness with high suction for 3 seconds. A universal adhesive (Prime & Bond universal) was then applied to the preparation walls and light cured for 20 seconds. A nanohybrid resin composite was then applied by firstly building a proximal wall in resin composite against the sectional matrix that was light cured while pressing the matrix against the adjacent tooth to assure tight proximal contact. Composite restoration was then inserted in horizontal increments of 2 mm thickness each and progressively light cured for 40 seconds/ each increment till completely filling the cavity. Before light curing of the superficial increment, initial shaping of the occlusal anatomical features was given with a special gold-plated composite applicator. The matrix was then removed, and final occlusal adjustments and finishing were performed using white stones.

An additional buccal and lingual light curing of 40 seconds each was performed to assure adequate conversion of the deeper layer of resin composite. Proximal contacts were checked with dental floss. Post operative bitewing radiographs were taken to assess the proximal contour of the restoration, any detectable marginal or interfacial discrepancies. Only restorations with tight proximal contacts and with no detectable marginal or interfacial discrepancies immediately after restoration was included in the study.

Other carious lesions were restored with resin composite restorations at respective clinical sessions.

Testing the biological effectiveness of the procedure

Following a planned schedule, patients were recalled at the respective study intervals of one week, three weeks, three months, six months, and 12 months for assessment of pulp sensibility and post restoration hypersensitivity of the tooth in question.

Percussion test and cold pulp testing were performed at each study interval according to the following scale:

- Percussion test:

  N= Normal response (not sensitive to percussion)

  +ve= exaggerated response

- Cold Pulp testing:

Ethyl chloride was sprayed on a small sponge (foam pellet) and applied on the cervical part of the buccal surface of the respective tooth. The response was verified with the adjacent and contralateral tooth. Sensibility testing was performed after isolation of the respective tooth with cotton rolls.

N= normal response (pain disappears immediately after removal of stimulus).

RP= reversible pulpitis (pain remains less than 10 seconds after removal of stimulus)

IP= irreversible pulpitis (pain remains more than 10 seconds after removal of stimulus)

Periapical radiographs are done at 3 months, 6months and 12 months to check periodontal space, intactness of lamina dura any periapical radiolucency. On the other hand, hypersensitivity was assessed following ALF Briso et al reported method by verbally questioning patients regarding hypersensitivity to cold drinks, hot drinks, sweets or chewing or spontaneous pain [14]

I- No hypersensitivity

II- Mild transient hypersensitivity of short duration less than one week

III- Persistent hypersensitivity for more than one week

IV- Spontaneous pain

Chi-Square test was used for statistical analysis at a level of significance $P \leq 0.05$.

TABLE (1) Materials used in the study

Material	Composition	Lot Number	Manufacturer
Fine Etch, Etchant	37% phosphoric acid gel	FE1242	Spident Co., Ltd, Incheon, Korea
Prime & Bond Universal	• Bi- and multifunctional acrylate • Phosphoric acid modified acrylate resin • Initiator • Stabilizer • Isopropanol • Water	1810000033	Dentsply Sirona Co., Ltd, USA
Neo Spectra ST	Nanohybrid composite with pre-polymerized fillers	2112000421	Dentsply Sirona Co., Ltd, USA

TABLE (2) Summarizes the results and P-values obtained at different study intervals

Interval	Test	Percussion test		Cold pulp testing			Post restoration hypersensitivity			
		N	+ve	N	RP	IP	I	II	III	IV
1 week	L	20	0	16	4	0	12	6	2	0
	S	20	0	13	7	0	8	9	3	0
p-values					**0.29**		**0.21**	**0.33**	**0.63**	
3 weeks	L	20	0	12	8	0	14	5	1	0
	S	20	0	10	10	0	11	6	2	0
p-values					**0.53**		**0.33**	**0.72**	**0.55**	
3 months	L	20	0	17	3	0	15	4	1	0
	S	20	0	16	4	0	12	6	2	0
p-values					**0.68**		**0.32**	**0.47**	**0.55**	
6 months	L	20	0	18	2	0	16	4	0	0
	S	20	0	16	4	0	14	4	2	0
p-values					**0.38**		**0.47**	**1**	**0.15**	
12 months	L	20	0	18	2	0	17	3	0	0
	S	20	0	17	3	0	16	4	0	0
p-values					**0.63**		**0.68**	**0.68**		

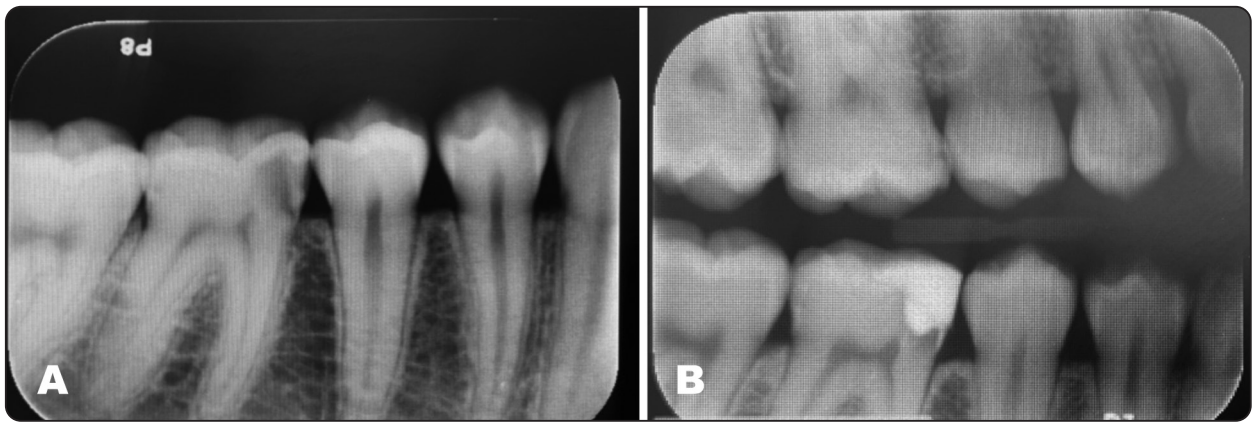

Fig. (1) Preoperative peri apical radiograph with proximal radiolucency D3 in lower first molar, (A), postoperative bitewing radiograph, (B)

RESULTS

None of the restored teeth showed positive response to percussion test at any interval of the study. None of the restored teeth showed sensibility response to cold pulp testing indicating irreversible pulpitis at any study interval. Moreover, patients did not report any persistent post-operative hypersensitivity at any of the study intervals.

None of the restored teeth showed radiographic changes indicating incidence of apical periodontitis.

There was a statistically insignificant differences between test groups for pulp vitality testing and post restoration hypersensitivity at different study intervals $P > 0.05$.

DISCUSSION

This prospective clinical study validates the association between partial caries removal in class II resin composite restorations with two different clinical endpoint of caries excavation and the outcome in terms of pulp vitality and post-restoration hypersensitivity over a period of 12 months. The current study is similar in design to pervious clinical studies [14]

Although stepwise and partial caries removal have received promising outcomes, the debate regarding the reliability of these procedures among clinicians and dental educational institutes remains with particular concern for the clinical endpoint of caries excavation in deep cavities. This might need long established clinical experiences [3,15] and a variety of complex clinical cases in educational and training programs of undergraduates and junior clinicians. Post restoration hypersensitivity and tooth vitality have been listed among the FDI biological properties of ranking restorations [16,17]. Therefore, the current study has used those two parameters for assessing the biological reliability of partial caries removal procedure. The literature provides inadequate reports that partial caries removal is a successful procedure that conserves pulp vitality and tooth structure [3,5] with progressing clinical trials to confirm the clinical reliability of the procedure. Two clinical end points of caries excavation, leathery/firm dentin or soft dentin have been reported with partial caries removal [3,5] with little information regarding the safety and validity of the procedure in both cases. In the present study cold pulp testing was used since it is a reliable and simple method of detecting pulp sensibility and can be used as a primary method of assessing pulp vitality in dental clinics [18]. The results of the current study showed that pulp vitality and post-restoration hypersensitivity are considered, none of the restored teeth presented persistent post-restoration hypersensitivity or irreversible pulpitis. This demonstrates the validity and effectiveness of the procedure of partial caries removal irrespective of the clinical endpoint of excavation or the depth of caries penetration in dentin D2 or D3 using the ADA clinical classification of caries [19]. However, a limitation remains that regardless of the clinical signs and symptoms indicating the vitality of the pulp, there is absence of an absolute reliable link between the clinical signs and symptoms and the actual histopathological status of the pulp[20,21]. Moreover, there is a lack of a strong evidence indicating the fate of remaining caries left at the depth of the cavity in partial caries removal [22,23].

Previous longitudinal clinical studies have used a sample size of 20 [24,25] In the current study, subjects' recruitment, and availability for follow up at different study intervals were among the main faced challenges which explain the relatively small sample size used that might add another study [26,27] limitation.

The results of the present study indicate more frequency of transient sensitivity and reversible pulpitis at different study intervals when soft caries is left at the deepest layer of dentin than when leathery/firm dentin is left behind with no significant difference in effect. At deeper locations the thickness of dentin bridge is less, and the diameter of dentinal tubules become greater while the progressing defensive response of the pulp which might be more pronounced when leathery/firm dentin is left behind at moderate cavity depth (D2) levels [27,28]. However, this has not significantly affected vitality pulp testing or post-restoration hypersensitivity results at any of the study intervals.

Universal adhesive systems have been reported for their superior bonding performance and flexibility of application as self-etch or etch and rinse with reported inferior bonding effectiveness to caries affected dentin [29,31]. To improve their bonding effectiveness, selective enamel etching strategy has been recommended [30,31,32]. In the present study universal bonding 3M universal adhesive has been used with selective enamel etching strategy to produce best possible peripheral sealing of

restorations so that remaining bacteria would die or remain inactive. Future studies should test bonding systems and bonding strategies.

The current study has been conducted over 12 months which was limited by patients' availability for recalls. Longer duration clinical study would have provided a broader perspective and more informative outcome. Moreover, it would have allowed assessing of the fate of residual caries over a longer period [31]. Future studies should consider other factors like the incidence of recurrent caries and carrying out systematic caries risk assessment and other patient related factors [11].

The guidance in determining the clinical endpoint in the current study for simplicity and ease of application, was the texture of dentin caries using hand spoon excavators that might be subjective. However, the effect is minimized since only one investigator has carried out the entire procedures and post restorative evaluation at the different study intervals. Nevertheless, future clinical studies should consider other minimal intervention techniques in determining the clinical endpoint of excavation like chemo-mechanical caries removal such as sodium hypochlorite and enzyme based minimal invasive methods[32,33,34], ceramic burs and polymer burs, caries detection dyes as well as fluorescence aided caries excavation[3].

In the current study, MDP containing universal adhesive has been used since MDP containing bonding agents have been reported for long term bond stability and anti-Matrix metalloproteinases effects thus resisting hybrid layer degradation over time [35].

CONCLUSION

According to the results of the present study and putting into consideration all its limitations, the following conclusions could be drawn:

1- Regardless of the clinical endpoint of caries excavation, partial caries removal appears to be a biologically safe procedure when pulp vitality and post-restoration hypersensitivity are considered.

2- Leaving behind some carious soft dentin in deep cavity locations produces similar frequency of transient post-restoration hypersensitivity and reversible pulpitis to leaving firm/ leathery dentin.

3- When cases are properly selected and cavities are appropriately restored, partial caries removal does not lead to irreversible pulpitis or persistent post operative hypersensitivity.

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