Review Article

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Dentistry Section

Quality of Marginal Seal at the Root Dentine-Margin Elevation Material Interface in Proximal Box Elevation Technique for Adhesive Indirect Aesthetic Restorations- A Systematic Review

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ABSTRACT

Introduction: A subgingivally extending proximal carious defect can be adequately restored with an adhesive indirect aesthetic restoration only when the proximal margins can be raised coronal to the Cementoenamel Junction (CEJ) using various Margin Elevation Materials (MEM). This approach is commonly referred to as the Proximal Box Elevation (PBE) technique. However, there is a lack of evidence in the literature regarding the quality of the marginal seal at the root dentine- MEM interface when using PBE technique.

Aim: The purpose of this systematic review was to summarise the available evidence on the the quality of the marginal seal at the root dentine- MEM when using the PBE technique during the placement of adhesive indirect aesthetic restorations.

Materials and Methods: Comprehensive electronic search was performed in PubMed Central, Cochrane Library and Google Scholar from their inception to January 2021 at the Department of Conservative Dentistry and Endodontics, Sri Ramachandra Institute of Higher Education and Research (SRIHER) between May 2020 to January 2021. Full text articles published in english language which have performed an indirect restoration with and without PBE technique were included in the review. A total of 249 articles were screened initially in the review. The main keywords used were: "PBE", "Cervical Margin Relocation (CMR)", "Deep Margin Elevation (DME)" and "coronal margin relocation". The review protocol followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The risk of bias assessment of the included studies was performed independently.

Results: A total of 9 in-vitro studies were included in the present systematic review. Resin based composites of different viscosities seemed to perform adequately as MEM. It may be prudent to perform the margin elevation in multiple layers. Self etch adhesives had a better marginal seal than the total etch adhesives. Regarding the effect of indirect restoration on the marginal seal at the root dentine- MEM interface, there was no conclusive evidence. PBE may provide a congenial environment for predictable and efficient bonding of indirect adhesive aesthetic restorations.

Conclusion: Based on the moderate quality of evidence from the included articles in this systematic review, it can be concluded that while performing a PBE technique, the quality of marginal seal at root dentine- MEM interface is satisfactory under in-vitro conditions.

Keywords: Carious lesion, Dental leakage, Flowable composite, Operative dentistry, Permanent dental fillings

INTRODUCTION

Management of proximal carious lesions of posterior teeth extending subgingivally poses a significant restorative challenge [1]. Considerations in the clinical management of such defects often include substantial loss of tooth structure, subgingival cervical margins and questionable sealing of the cervical margins in the absence of enamel [2]. Difficulty in accessing and isolating these defects makes bonding challenging, potentially jeopardising the success of the definitive restorations [3]. Indirect restorations are often the modality of choice for restoring such extensive defects extending subgingivally [4].

Predictable bonding of the adhesive indirect aesthetic restorations to a subgingival tooth margin with different adhesive techniques is challenging due to the ultrastructure of the tooth substrate in the root portion [5,6]. Dietschi D and Spreafico R introduced the technique of Cervical Margin Relocation (CMR) to coronally relocate the subgingival proximal margins by using a 'flexible' adhesive base of a pliable composite resin underneath an adhesive indirect aesthetic restoration [7]. Over the years, this technique has also been described as Deep Margin Elevation (DME) or coronal margin relocation or Proximal Box Elevation (PBE) [8].

Resin based composite was advocated as the material of choice by Dietschi D and Spreafico R for the PBE technique [7]. The effect of polymerisation stress of composite resin material is well known and is inevitable while performing the procedure. In this regard some other authors have favoured the use of flowable composite resins, with a lower modulus of elasticity [9-12]. Some authors have recommended the use of resin-modified glass ionomer as a base material to perform PBE, primarily because of its predictable chemical adhesion and fluoride release [5,12-15]. There is also no particular categorisation or terminology existing for addressing these materials used for elevating the cervical margins for PBE. Hence, the authors of this systematic review propose a new terminology, MEM to denote the materials used for PBE.

An existing narrative review has evaluated the role of CMR in indirect restorations and has emphasised the importance of evaluating the root dentine- MEM interface which would be located more subgingivally [12]. But the longevity of an indirect restoration is also dependent on the marginal quality at the root dentine- MEM interface [16-18]. However, to the best of authors knowledge, there were no previously published systematic reviews evaluating this interface, while bonding an indirect adhesive aesthetic restoration. Hence, the aim of this systematic review was to analyse the quality of marginal seal at root dentine-MEM interface subjected to PBE technique in restoring proximal subgingival carious defects with indirect adhesive aesthetic restorations.

MATERIALS AND METHODS

The current systematic review was conducted at Department of Conservative Dentistry and Endodontics, Sri Ramachandra Institute of Higher Education and Research, SRIHER (DU) from May 2020 to January 2021.

Protocol

A focused question was constructed based on the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [19].

Literature Search Strategy

A comprehensive literature search was performed in PubMed Central, Cochrane Library and Google Scholar from its inception till January 2021. The main keywords used were: "PBE", "CMR"; "DME" and "coronal margin relocation". Further searches were carried out manually by exploring the cross references of the initially retrieved articles and by exploring websites of the concerning journals. The search strategy along with keywords used for the search is depicted in [Table/Fig-1].

Keywords	Data base	No. of articles
marginal integrity OR marginal adaptation OR microleakage OR (adaptation, dental marginal [MeSH Terms] AND proximal box elevation OR deep margin elevation OR cervical margin relocation AND tooth coloured indirect restoration OR indirect aesthetic restoration OR ceramic inlay OR ceramic onlay OR ceramic overlay OR composite inlay OR composite onlay OR composite overlay OR cad cam [MeSH Terms]	PubMed Central	15
proximal box elevation (OR) deep margin elevation (OR) cervical margin relocation (OR)	Cochrane library	18
Proximal box elevation	Google Scholar	214
Deep margin elevation		
Cervical margin relocation		
Indirect restorations		
Inlays/onlays/CAD/CAM restorations		

[Table/Fig-1]: Keywords used for the search in databases.
CAD/CAM: Computer-aided design and computer-aided manufacturing
*Hand searching in 2 articles

Research Question

The PICOS was defined in terms of Population (P)- extracted human molar teeth; Intervention (I)- indirect adhesive aesthetic restorations with PBE; Comparison (C)- indirect adhesive aesthetic restorations without PBE; Outcome (O)- marginal seal between MEM and root dentine; Study design (S)- in-vitro studies.

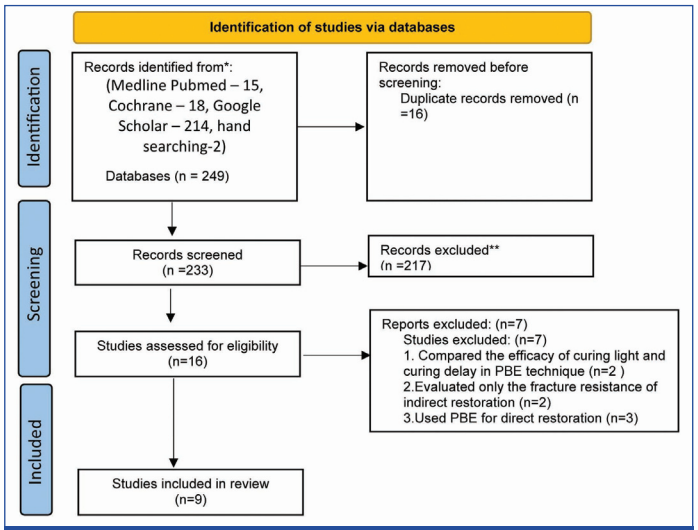
Eligibility Criteria

Inclusion criteria: a) In-vitro studies in extracted molar teeth restored with indirect adhesive aesthetic restorations utilising PBE technique; b) Articles which evaluated the marginal seal associated with PBE technique; c) Full text articles published in English language.

Exclusion criteria: a) Clinical case reports, case series, and animal studies; b) In-vitro studies in posterior molar teeth with subgingival defects restored with direct aesthetic restorations with/without PBE; c) In-vitro studies conducted in posterior teeth with subgingival defects restored with indirect adhesive aesthetic restorations without PBE.

Literature Search

Literature search was performed by three reviewers who were trained in executing the search and using the Boolean operators (SS, CA and MK). The search strategy employed in the present systematic review has been depicted in [Table/Fig-2]. A total of 249 articles were identified from the electronic database search and hand searching. After removal of duplicates and screening of the titles and abstracts, a total of 233 were excluded. After full text analysis of the 16 articles researching on in-vitro studies on PBE, seven articles were excluded. The shortlisted nine articles were included in the final qualitative analysis for the systematic review [16-18,20-25].



[Table/Fig-2]: A flowchart of the literature search process.

Data Extraction Process

During the initial screening, two reviewers (SS and CA) independently evaluated the titles and abstracts of consolidated articles from the search that encompassed the research question. A full text screening was carried out to evaluate if the included articles met the inclusion criteria. Any disagreements in the inclusion of the articles or data extraction were clarified and resolved with a third reviewer (AG). Any additional or missing information needed from the included articles were obtained from the authors of the article. The data extraction form was created with following details: author/year, sample size, type of comparison, dimensions of the cavity prepared, location of the proximal box margin, material used for indirect restoration, adhesive system used, luting agent used, ageing process and the assessment of marginal seal at the interface between the MEM and root dentine.

Risk of Bias Analysis

Risk of Bias of the included studies was assessed based on the previously published methodology for evaluation of in-vitro studies [26]. Risk of bias analysis was evaluated based on the included articles' description of following criteria randomisation of teeth, use of teeth without caries/defects, use of teeth with similar anatomy, use of MEM material according the manufacturer instructions, whether the tooth preparation and PBE procedures were performed by the same operator, description of sample size calculation, presence of control group and blinding of evaluator/assessor.

RESULTS

Study Characteristics

The overview of the main characteristics, the materials employed, and the designs of the reviewed studies are reported in [Table/Fig-3]. The sample size in the included studies varied between 14 to 88 teeth consisting of human mandibular first, second and third molars. The adhesive indirect aesthetic restorations included inlays [16,18,20] onlays [20] overlays [22-24] and crowns [17,21,25] and were fabricated using laboratory composites, CAD/CAM hybrid resin ceramic and Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) milled glass ceramic and feldspathic ceramic blocks.

Author and year	Sample size	Type of intervention	Dimension of cavity prepared	Material used for indirect restoration and design of indirect restoration	Adhesive system used	Luting agent used	Method used for ageing	Assessment test	Interfaces evaluated	Inference
Roggendorf MJ et al., 2012 [16]	40	5 Groups: **Group 1, 2-** PBE with self-adhesive cements (G-Cem, Maxcem Elite), **Group 3-** PBE in 1 layer (Clearfill Majesty Posterior); **Group 4-** PBE in 3 layers and Group 5- Control (Without PBE)	Standardised class II cavity preparations (MOD, 4 mm in width bucco-lingually at the isthmus, 3 mm in depth occlusally, 2 mm in depth at the bottom of the proximal box	MOD inlay- Clearfil majesty posterior ceramic inlays	AdheSE	Syntac and variolink	Chewing simulator for 1,00,000 cycles at 50N followed by thermocycling 2500 cycles between 5°C and 55°C	Scanning Electron Microscope (SEM) at 200X magnification	1.Indirect restoration and luting agent 2.lutimg agent and MEM 3.MEM and root dentine	Placement of composite restoration in incremental layers for PBE procedure was effective in bonding to deep proximal margins.
Zaruba M et al., 2013 [17]	40	4 Groups. **Group 1:** Positive control in enamel (without PBE); **Group2-** PBE with 1 layer (Tetric); Group 3- PBE with 2 layers (Tetric); **Group 4-** Negative control in dentine (Without PBE)	Standardised non bevelled Mesial-Occlusal-Distal (MOD) class II-cavity preparation	MOD inlay- Feldspathic ceramic	Syntac, Heliobond	Tetric	Thermomechanical loading was carried on by repeated thermal and mechanical stresses in a computer-controlled masticator (CoCoM 2, PPK, Zürich, Switzerland) for 1.2 Mio cycles with 49 N at 1.7 Hz.Thermal cycling was carried out during the loading cycles by flushing water with temperature changing 6000 times from 5--50°C	SEM at 200X magnification	1. Tooth--luting composite with margins in enamel 2. MEM and root dentine 3. Luting composite--inlay	Placement of a composite restoration for PBE before insertion of a ceramic inlay had no difference from placing the restoration on dentine.
Frankenberger R et al., 2013 [18]	48	6 Groups: **Group 1, 2 and 3-** PBE with self adhesive cements (RelyX Unicem, Maxcem Elite and G-Cem) **Group 4-** PBE with 1 layer (Clearfill Majesty Posterior), **Group 5-** PBE with 3 layer (Clearfill Majesty Posterior) and **Group 6-** Control (Without PBE)	Standardised class II cavity preparations (MOD, 4 mm in width bucco-lingually at the isthmus, 3 mm in depth occlusally, 2 mm in depth at the bottom of the proximal box	Ceramic inlays- IPS Empress CAD glass	Adhese universal	Syntac and Variolink II.	Thermomechanical loading 100,000 cycles at 50 N at a frequency of 0.5 Hz. The specimens were simultaneously subjected to 2,500 thermal cycles between +5°C and +55°C by filling the chambers with water in each temperature for 30 s.	SEM at 200X magnification	1. Indirect restoration and luting agent 2. lutimg agent and MEM 3.MEM and root dentine	Meticulous layering of composite restoration in PBE technique can be considered as a alternative to ceramic bonding to dentine in deep carious subgingival lesions.
Ilgenstein I et al., 2015 [20]	48	4 Groups: **Group 1, 2-** PBE with two 1mm layers of Composite (Tetric EvoCeram), **Group 3 and 4-** Control (Without PBE)	2 mm clearance on buccal and lingual cusps for onlaypreparation. Occlusal width of half of intercuspal distance	MOD onlay 1.Felspathic ceramic blocks 2.Composite resin blocks	Scothbond universal	RelX ultimate	Thermal and mechanical loading for 1.2 Mio cycles with 49 n at 1.7 Hz. Thermocycling for 3000 cycles between 5°C and 50°C.	SEM at 200X magnification	1. MEM and root dentine 2. Indirect restoration and luting composite	PBE had no impact on the marginal integrity of molars restored with feldspathic ceramic onlays. CAD/CAM onlays were more favourable than ceramics, particularly in tooth without PBE.
Spreafico R et al., 2016 [21]	40	4 Groups: **Group 1 and 3-** PBE with two 1mm layers of flowable composite (Filtek Supreme XTE Flowable Resin), **Group 2 and 4-** PBE with two 1 mm layers of composite (Filtek Supreme XTE resin)	Occlusal reduction of at least 1.5 mm was performed. Following this, an axial reduc- tion of 1.0 mm was performed with a 1.0-mm rounded shoulder	Crowns. 1.Cerec e-Max 2. RNCblocks(3M)	Optibond	Relay X ultimate	Functional loading with a chewing simulator followed by thermocycling 7800 cycles between 5-50° C	SEM at 50X magnification	1. MEM and root dentine 2.Indirect restoration and Luting composite	PBE can be considered as an adequate procedure for relocation of deep proximal margins. There was no difference in marginal seal before and after thermocycling.
Koken S et al., 2018 [22]	39	3 Groups: **Group 1-** Two 1mm increments of viscous composite (Essentia: GC), **Group 2-** Two 1mm increments of flowable composite (G- Aenial) and **Group 3-** Control (Without PBE)	2 mm reduction for cuspal coverage. Proximal preparations, 1.5 mm mesiodistally, 4 mm buccolingually.	Overlay- GC cerasmart	G multi primer	GC link force	NA	Marginal Seal: Silver nitrate solution was used to assess the marginal seal under a digital microscope at 1X, 3X and 6X magnification.	1.MEM and root dentine 2.Indirect restoration and root dentine	The marginal sealing ability of flowable composites was comparable to microhybrid composites for PBE technique. Bonding of overlays to dentin appeared to have less microleakage at the interface than bonding to a MEM.

Koken S et al., 2019 [23]	20	3 Groups: **Group 1-** Two 1mm increments of viscous composite (Essentia: GC), **Group 2-** Two 1mm increments of flowable composite (G- Aenial) and **Group 3-** Control (Without PBE)	MOD cavity, Box-shaped preparations were made, 2 mm in the mesio-distal and 5 mm in bucco-lingual direction.	Overlay-Hybrid ceramic CAD-CAM;	OptiBond FL G-Premio BOND	G-Multi Primer and G-CEM Link Force	-	MARGINAL SEAL: Silver nitrate solution was used to assess the marginal seal under a digital microscope at 1X, 3X and 6X magnification.	1.MEM and root dentine 2.Indirect restoration and root dentine	A 3 step total etch can be effective than a total etch adhesive in providing an adequate marginal seal during the PBE procedure.
Juloski J et al., 2020 [24]	14	2 Groups: **Group 1-** two 1mm increments with Premise flowable (Kerr) bonded with 3- step total-etch bonding system (Optibond FL, Kerr). Resin composite overlays luted with NX3 Nexus (Kerr), in combination with the same adhesive (OptiBond FL). **Group 2-** two 1 mm increments with Tetric EvoFlow Bulk Fill (Ivoclar Vivadent) bonded with Adhese Universal (Ivoclar Vivadent). Resin composite overlays with Variolink Esthetic DC (Ivoclar Vivadent) in combination with Adhese Universal in selective enamel etch mode.	MOD cavity, Box-shaped preparations were made, 2 mm in the mesio-distal and 5 mm in bucco-lingual direction.	Hybrid ceramic CAD-CAM; overlay	Optibond Adhese Universal	NX3 Nexus Variolink	-	SEM at 50X and 200X magnification MARGINAL SEAL: Silver nitrate solution was used to assess the marginal seal under a digital microscope at 1X, 3X and 6X magnification.	1. MEM and root dentine 2. MEM and luting composite 3. Indirect restoration and luting composite 4. Indirect restoration root dentine	1.PBE provides less adequate marginal seal than bonding directly to dentin. 2. Differences in marginal seal provided by different materials could not be evaluated by SEM.
Grubbs TD et al., 2020 [25]	45	5 Groups: **Group 1-** GIC (3mm increment- Fuji IX GC), **Group 2-** RMGIC (Two 1.5mm increment- Fuji II LC), **Group 3-** Resin based composite (Two 1.5 mm increment- Filtek Supreme Ultra), **Group 4-** Bulk fill composite (3mm increment) and **Group 5-** Control (Without PBE)	MOD Onlays- 1mm pulpal depth, mesially1mm to the CEJ, distally 2 mm apical to the CEJ	CEREC	Scotch bond universal adhesive	Rely X ultimate	Mechanical loading under 65N , 1.2 Hz cyclic load for 100,000 cycles in 37^0 water bath.	SEM at 200X magnification	1.MEM and root dentine 2. MEM and indirect restoration	The material used for PBE technique did not influence the marginal quality, concluding that these materials are suitable for PBE.

[Table/Fig-3]: General characteristics of the included articles.
MOD: Mesio-occlusodistal; CEJ: Cemento-enamel junction; CAD/CAM: Computer-aided design and computer-aided manufacturing, MEM: Margin elevation material; PBE: Proximal box elevation

Effect of MEM on Marginal Seal

Among the included studies, 6 studies [16,18,21,22,24,25] evaluated different materials for PBE technique. Resin based composites in different viscosities like flowable and bulk fill were evaluated in four among the six studies [16,21,22,24,21]. Grubbs TD et al., on evaluating RMGIC, GIC, resin based composites and bulk fill composites concluded that there was no statistical difference in the marginal seal achieved at the MEM root dentine interface [25]. Koken S et al., stated that the performance of flowable and microhybrid composites were comparable for PBE technique [22]. Roggendorf MJ et al., on comparing luting adhesive resin cements and restorative composite as MEM, stated that bonding indirect restoration to dentine had similar marginal seal as bonding to the MEM applied in multiple layer [16]. Spreafico R et al., stated that there was no difference in the marginal seal achieved when flowable and conventional composite were used as a MEM in root canal filled teeth. It was also stated that since flowable composites have a better flow, this property can be used to ease the placement of the composite increment in the subgingival margin [21]. Juloski J et al., stated that flowable and bulk fill composite had the same marginal adaptation at the MEM/ root dentine interface [24]. The study by Zaruba M et al., and Frankenberger R et al., supported the fact that MEM in incremental layers produced less gap free margins at the resin dentine interface [17,18]. Another study by Koken S et al., stated that bonding an indirect restoration with a 3 step total etch bonding system resulted in better marginal seal at the MEM root dentine interface than an universal adhesive when composite was used as the MEM [23].

Effect of Indirect Restoration on Marginal Seal

Two groups studied restorations fabricated by CAD/CAM technology in restoring teeth with PBE. Onlays milled of feldspathic ceramic and composite resin blocks with nanoceramic fillers were evaluated by Ilgenstein I et al., while the other study by Spreafico R, et al., evaluated crowns made of the same resin nanoceramic composite blocks and crowns made of lithium disilicate [20,21]. While no significant differences in marginal integrity were associated with both types of crowns either with or without PBE procedure, resin composite nanoceramic onlays exhibited better overall marginal integrity compared to ceramic onlays [21]. Koken S et al., on comparing flowable and microhybrid composites as MEM for luting CAD/CAM overlays, concluded that both the materials were comparable for PBE technique and bonding the indirect restoration to dentine has lesser marginal leakage [22].

Criteria	Roggendorf MF et al., (2012) [16]	Zaruba M et al., (2013) [17]	Frankenberger R et al., (2013) [18]	Ilgenstein I et al., (2014) [20]	Spreafico R et al., (2016) [21]	Koken S et al., (2018) [22]	Koken S et al., (2019) [23]	Juloski J et al., (2020) [24]	Grubbs TD et al., (2020) [25]
Randomisation of teeth	-	+	-	+	-	+	+	+	+
Use of teeth without caries/defects	+	+	+	+	+	+	+	+	+
Use of teeth with similar anatomy	+	+	+	+	+	+	+	+	-
Use of PBE material according to manufacturer instructions	?	?	?	+	+	+	+	+	+
Tooth preparation, PBE, cementation of indirect restoration by the same operator	?	?	?	?	?	?	?	?	?
Description of sample size calculation	-	-	-	-	-	-	-	-	-
Presence of control group	+	+	+	+	+	+	+	+	+
Blinding of evaluator/assessor	+	-	+	?	+	?	?	+	-

[Table/Fig-4]: Risk of bias assessment of the included studies.
+ Yes (If the defined question was answered in the article); - No (If the defined question was not answered in the article); ? Unclear (If the defined question was not clearly given in the article; Articles with a high risk of bias-4 (Roggendorf MJ et al., [16] Zaruba M et al., [17], Frankenberger R et al., [18], Grubbs TD et al., [25];Articles with a medium risk of bias- 5 (Ilgenstein I et al., [20], Spreafico R et al., [21], Koken S et al., [22], Köken S et al., [23], Juloski J et al., [24])

Risk of Bias Analysis

Risk of Bias of the included studies was assessed based on the previously published methodology by Sarkis-Onofre R R et al., who had used a modified version to evaluate the quality of the evidence in in-vitro studies [26]. If the defined question was answered in the article the corresponding article was given Yes (+) on that specific criterion, No (-) if the defined question was not answered in the article and Unclear (?) if the defined question was not clearly given in the article.

Articles that reported one to four criteria were classified as having high risk of bias, five or six criteria as medium risk of bias, and seven or eight criteria as low risk of bias [26]. Based on the number of "Yes" each article had obtained, the articles were classified as high risk (1-4), medium risk (5 or 6) and low risk (7 or 8) [Table/Fig-4]. It was found that all the included articles had answered two criteria (use of teeth without caries/defects and the presence of control group), however none of the included articles described about the sample size calculation and did not mention whether single operator performed all the procedures. Three studies [16,18,21] did not mention randomisation of teeth, one study did not use the teeth with similar anatomy [25], three studies did not clearly mention about the MEM usage according to the manufacturer instruction [16-18], five studies did not blind the evaluator/assessor [17,20,22,23,25].

After the analysis, four studies were classified as having high risk of bias [16,17,18,25]; five studies were classified as having medium risk of bias [20-24] . The over all level of evidence of the systematic review was considered moderate.

DISCUSSION

The "open sandwich technique" used for restoring subgingival defects with direct composite restorations, served as the basis for the evolution of the PBE technique [27]. Arising from this ideology, the PBE technique was proposed as a linear approach to be applied for adhesive indirect aesthetic restorations with composite resin as the MEM, for relocation of the cervical margin by Dietschi D and Spreafico R [7]. The marginal gap occurring at the two interfaces, namely the indirect restoration-MEM and root dentine-MEM is the most important factor that has to be evaluated to assess the success of bonding an indirect restoration through the MEM to the root dentine using the PBE technique. The interface between the root dentine-MEM being subgingival and apical to the CEJ becomes a potential site for biofilm accumulation and microleakage, affecting the predictability of the bond at the root dentine-MEM. This might have an effect on the longevity of the indirect restoration [12]. So this systematic review focused on evaluating the quality of the marginal seal at the most critical root dentine-MEM interface.

Initially, the use of composite resin material was advocated as a MEM [7]. In this systematic review, the included articles used different viscosities of resin based composite (conventional, flowable, bulkfill, bulkfill flowable, hybrid and luting). Roggendorf MF et al., and Frankenberger R et al., compared the luting and restorative composite and stated that luting composite materials are not recommended as a MEM [16,18]. Though flowable composites were advocated because of their easy handling properties, their inferior mechanical properties could have been the reason for them to have less gap free margins at the MEM root dentine interface [28]. On the contrary, there was no difference between flowable and conventional resin composite as MEM [21,22,24] . Only one study by Grubbs TD et al., in addition to resin based composite, evaluated both RMGIC and GIC as a MEM. Though RMGIC had more gap free margins than composites, it was not statistically significant. So, it was concluded that all the materials performed similarly under the in-vitro conditions [25]. Köken S et al., compared different types of indirect restorations with composites as the MEM of choice stated that both the flowable and conventional/traditional packable resin based composite can be used as a successful MEM for PBE procedure [23].

Adhesion between the MEM and root dentine is very critical since high occurrence of marginal seal failure happens at this interface [12]. In this review, all the included articles used either self etch adhesives [16,18,22,23] or total etch adhesives [17,20,21,25]. Only one study compared the total etch and self etch adhesives and concluded that significantly better marginal seal was achieved with self etch adhesives [24]. Köken S et al., found that luting an indirect restoration with three step adhesives resulted in a better marginal seal between MEM and root dentine when compared with self etch adhesives [23]. Two of the included studies also supported the statement that, self etch adhesives should not be considered as the material of choice for luting an indirect restoration in combination with a PBE technique. Both the studies noted less gap free margins at the MEM- root dentine interface when the self etch adhesive was used [16,18]. Bonding to cervical root dentine is always critical since dentine substrate contains more amount of organic component [12] and also risks of over etching of subgingival dentine need to be considered when using the total etch adhesives [29]. From the included articles of the systematic review, it appears that self etch adhesives are more conducive for bonding the MEM to the root dentine. Vis-à-vis, bonding the indirect restoration to tooth with the elevated proximal margin, total etch adhesives are pertinent, as there is adequate enamel at the occlusal cavity to facilitate bonding [22,23].

Layering the composites in increments is said to reduce the polymerisation shrinkage and increase the bond strength of

composite resins [21]. All the included studies in this review performed PBE technique with incremental layering in any one of the treatment groups. Zaruba M et al., Koken S et al., and Grubbs TD et al., did not find the significant influence of multiple layering of MEM over single layer [17,23,25]. However, two included studies concluded that three consecutive 1 mm increments of resin based composites were superior to single increment of composite in order to make the PBE technique a sustainable clinical procedure [16,18].

On evaluating the influence of indirect restorations on marginal seal between MEM and root dentine, contrasting results have been exhibited under different study settings. On one hand, better marginal seal and fracture resistance was exhibited by CAD/CAM composite onlays without PBE than ceramic restorations [20]. On the other hand, no significant difference in the marginal integrity were found for different viscosity of resin composites used for MEM under either resin nanoceramic or lithium disilicate crowns [21]. These observations, however, must be analysed critically as the indirect restoration was a full coverage crown, which may have been responsible for this result.

Scanning Electron Microscope (SEM) and microleakage analysis have been most commonly used method to evaluate the marginal seal between the MEM and root dentine interface in the included studies [16-18,20-25]. The study by Juloski J et al., focused on evaluating the quality of the margins produced following PBE procedure using different materials to critically analyse the reliability and relatability of the results obtained by SEM examination and microleakage analysis. No statistically significant relationship was depicted in the results obtained amongst the two methods used for evaluation of the quality of the margins suggesting that either SEM or microleakage analysis was suitable for margin quality assessment. However, they also critically found that the results revealed the presence of statistically significant differences with microleakage analysis but there was an absence of differences in the SEM analyses between the two groups at PBE sites. This seemed to suggest that the data provided by these two methods was not consistent [24]. The possible explanation by the authors of the study was that there would have been visual challenges in identifying the site of bond disruption and will also be dependent on the degree of magnification that was used to evaluate the margins [24].

Limitation(s)

The results in the included studies had a wide range of heterogenicity with differences in methodology, the type of MEM used, type of adhesives used, the type of indirect restoration adhesive and luting procedures for cementation of indirect restoration and the assessment of outcome. So, it was not feasible to compare the results of the included studies.

It has to be noted that there exists another interface, i.e., the interface between the luting agent (used for cementation) and the indirect restoration, which was not evaluated in few studies [22,23]. The details of luting agent interface were not given. Future studies should be directed in evaluating crucial interfaces, i.e., root dentine-MEM, MEM -luting agent, luting agent-indirect restoration, which will also have a role in longevity of the indirect restoration.

At present, reliable knowledge about PBE comes primarily from laboratory studies; nevertheless the use of resin based composite resins for PBE seems to be a viable and reasonable treatment option. There is a lack of strong evidence on the clinical performance of teeth with an indirect restoration in a relocated margin. Although the results from the studies could be extrapolated, it was not possible to pronounce a particular ideal approach, since the outcomes of the studies were different; the authors of the review were not able to come to a conclusion. Robust methodology using appropriate techniques and application of suitable materials should be done in further studies with focus on the critical interface between the MEM and cervical dentine. Also, clinical performance and survival being a complex issue, needs to be evaluated by clinical trials especially with regard to the maintenance of marginal integrity and the impact on PBE procedure on periodontal health.

CONCLUSION(S)

The marginal quality at interface between the root dentine and the MEM appeared to be satisfactory under in-vitro conditions as has been observed by various studies. So, performing proximal margin elevation can be considered a suitable alternative in situations of restricted intraoral access to the subgingival defects, where maintaining isolation and bonding to dentine will be a challenge. Resin based composites of different viscosities seem to perform adequately as a MEM. It may be prudent to perform the margin elevation in multiple layers. Proximal Box Elevation (PBE) may provide a congenial environment for predictable and efficient bonding of indirect adhesive aesthetic restorations. However, future research on influence of different adhesive system is recommended to derive a definitive recommendation for the type of adhesives for PBE technique.

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