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Review Article

Cervical Margin Relocation for Indirect Bonded Restorations: A Literature Review

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Abstract:

Large posterior defects located beneath the gingival tissues complicate the use of indirect bonded restorations. It probably invades the biological width, during rubber dam isolation, impression taking and adhesive procedures. This article proposes a literature review of a new minimally invasive technique known as cervical margin relocation which allows to relocate subgingival margin to supragingival level using an appropriate material. A literature search was conducted in the Medline/PubMed database following the main key words: "cervical margin relocation», «deep margin elevation", "proximal box elevation", "indirect restorations", "adhesion", "marginal adaptation", "subgingival margin". A total number of 44 articles were included.

Based on the reviewed literature, it can be concluded that cervical margin relocation technique emerged as an interesting alternative to surgical crown lengthening. However, further research, scientific evidence and randomized clinical trials with longer follow-up results are needed to clarify essentially the longevity of this technique and its compatibility with periodontal tissues.

Keywords: Cervical margin relocation, partial indirect restorations, bonding, ceramic, resin, marginal adaptation, periodontal health.

1- Introduction

Class II restorations in the posterior area with medium to large-sized cavities and deep margins usually require indirect restorations to restore morphological and functional integrity.

In such cases, cavities located beneath the gingival tissues complicate the use of indirect bonded restorations during isolation with a dental dam, adhesion procedures, impression taking, and final positioning of the restoration itself and subsequently impede their durability and relationship with the periodontal tissues (1).

Thus, a variety of approaches can be employed. Surgical procedure is too mutilating for the periodontium tissue with a risk of furcation involvement, dentin hypersensitivity as well as inadequate crown/root ratio. On the other hand, orthodontic extrusion is too expensive and can take months with an average time of 4 to 6 weeks (2).

Recently, a more conservative approach known as cervical margin relocation (CMR), proximal box elevation (PBE), or deep margin elevation (DME) was introduced in 1997 by Dietschi and Spreafico. This technique proposes application of an appropriate material in the deepest parts of the proximal areas to reposition the cervical margin supragingivally (3,4).

The aim of this literature review is to summarize the articles determining the cervical margin relocation for indirect bonded restorations.

2- Materials and methods

A variety of keywords and their combinations were used as a key: "cervical margin relocation", "deep margin elevation", "proximal box elevation", "indirect restoration", "adhesion", "marginal adaptation", "subgingival margin".

Articles were searched without date restriction in the Medline/PubMed database. Studies only in English were taken into consideration and only information referring to indirect adhesive restoration, as a type of final restoration, were included.

3- Results

In our review, a total of 44 references including 17 in vitro studies were used. The literature data provided information on marginal adaptation, fracture resistance, bond strength, and periodontal health. Information about the authors, the study design, and the main findings are summarized. The research findings are presented in the following table.

3.1. Review of in vitro studies

Author	samples	Tested parameters	CMR material	Type of the final restoration	Results
Roggendorf and al. (5)	40 third molars	-Marginal adaptation	1- self-adhesive resin cement (G-Cem) 2- self-adhesive resin cement (Maxcem Elite) 3- Hybrid resin composite (Clearfil Majesty Posterior) in one layer of 3 mm + self-etch adhesive (AdheSe) 4- Hybrid resin composite (Clearfil Majesty Posterior) in three layers of 1 mm each + self-etch adhesive (AdheSe)	Laboratory made composite inlays (Clearfil Majesty Posterior)	Bonding resin composite inlays directly to dentine showed similar amounts of gap- free margins compared to PBE applied in three consecutive layers. The groups with self-adhesive resin cements for PBE exhibited significantly more gaps in dentine.
Rocca and al. (6)	32 third molars.	-Marginal adaptation	1-Flowable composite (Premise Flow) + etch-and-rinse adhesive (Optibond FL) 2- Hybrid resin composite (Premise) + etch-and-rinse adhesive (Optibond FL)	Laboratory made composite inlays (Premise)	The marginal adaption to cervical dentin has shown no influence of the liner presence. The results support the use of flowable or restorative composites.
Zaruba and al. (7)	40 molars	-Marginal adaptation	1-Hybrid resin composite (Tetric) in one layer of 3 mm + etch-and-rinse adhesive (Syntac classic) 2- Hybrid resin composite (Tetric) intwo layers of 1.5 mm each + etch-and-rinse adhesive (Syntac classic)	Feldspatic ceramic inlays (Vitablocs Mark II)	Margin elevation technique results in marginal integrities not different from margins of ceramic inlays placed in dentin.
Frankenberger and al. (8)	48 third molars	-Marginal adaptation	1- self-adhesive resin cement (RelyX Unicem) 2- self-adhesive resin cement (G-Cem) 3- self-adhesive resin cement (Maxcem Elite) 4- Hybrid resin composite (Clearfil Majesty Posterior) in one layer of 3 mm + self-etch adhesive (AdheSe) 5- Hybrid resin composite (Clearfil Majesty Posterior) in three layers of 1 mm each + self-etch adhesive (AdheSe)	leucite-reinforced glass-ceramic inlays (IPS Empress CAD)	Bonding ceramic inlays directly to dentine showed similar amounts of gap free margins compared to PBE applied in three consecutive layers. Self-adhesive resin cements are not suitable for this indication.
Sandoval and al. (9)	32 third molars	-Marginal adaptation	1-Flowable composite (Premise Flow) + etch-and-rinse adhesive (Optibond FL) 2- Hybrid resin composite	leucite-reinforced glass-ceramic inlays (IPS Empress CAD)	PBE results in marginal integrities not different from margins of ceramic inlays placed in dentin.

			(Premise) + etch-and-rinse adhesive (Optibond FL)		
Ilgenstein and al. (10)	48 mandibular molars	-Marginal adaptation -Fracture resistance	1-Hybrid resin ((Tetric EvoCeram) in 2 layers of 1 mm each + etch-and-rinse adhesive (Optibond FL)	1-feldspatic ceramic onlays (Vita Mark II) 2- resin composite with nanoceramic fillers onlays (LAVA Ultimate)	PBE had no impact on either the marginal integrity or the fracture behavior of root canal-treated mandibular molars restored with feldspathic ceramic onlay.
Müller and al. (11)	24 molars	-Marginal adaptation	1-Hybrid resin (Filtek Supreme XTE) in one layer of 2 mm + etch-and-rinse adhesive (Scotchbond MP)	1- resin composite with nanoceramic fillers inlays (LAVA Ultimate)	The marginal integrities of bonding inlays directly to dentine are not different from bonding inlays to a proximal box, which has been elevated by a composite filling material.
Köken and al. (12)	39 molars	-Marginal adaptation	1-Hybrid resin (GC Essentia MD) in 2 layers of 1 mm each + universal adhesive (GC G-Premio Bond) 2-flowable composite (G-ænial Universal Flo) in 2 layers of 1 mm each + universal adhesive (GC G-Premio Bond)	1- hybrid ceramic CAD/CAM Block overlay (Cerasmart)	Bonding the overlay directly to dentine showed significantly less nanoleakage. The median leakage score was 2 for both composites used for PBE and 1 for the group without PBE.
Juloski and al. (13)	20 third molars	-Marginal adaptation	1- flowable composite (G-anial Universal Flo) + Universal adhesive (G-Premio BOND)	1-hybrid ceramic CAD/CAM Block overlays (GC Cerasmart)	Statistically significant difference existed in microleakage scores between CMR and non-CMR sites. Results showed that significantly higher microleakage was present on CMR sites.
SWA Ali and al. (14)	24 mandibular first molars	-Marginal adaptation -Fracture resistance	1-Hybrid resin (IPS Empress direct) + Universal adhesive (All bond universal)	1-Lithium disilicate reinforced glass-ceramic endocrowns (IPS e.max CAD) 2-Hybrid ceramic endocrowns (Vita Enamic)	Deep marginal elevation enhances both marginal adaptation and fracture resistance of IPS e.max CAD and Vita Enamic.
Vertolli and al. (15)	40 third molars	-Fracture resistance	1-glass ionomer (Fuji IX) 2-resin modified glass ionomer	1-feldspathic ceramic inlays	Deep marginal elevation resulted in decreased ceramic fracture when preparation margins were located below the cementoenamel junction.
Bresser and al.	60	-Fracture	1-Hybrid resin (Essentia	1- Lithium	DME did not affect the

(16)	mandibular molars	resistance	Universal composite) in one layer of 2 mm + etch-and-rinse adhesive (Optibond FL)	disilicate glass ceramic inlays (IPS e.max CAD) 2-1- Lithium disilicate glass ceramic onlays (IPS e.max CAD)	fracture strength of restorations, the repairability of fractures or fracture types to a statistically significant level.
Grubbs and al. (17)	75 first and second mandibular molar	-Marginal adaptation -Fracture resistance	1-glass ionomer (Fuji IX) in one layer of 3 mm 2-resin-modified glass ionomer (Fuji II LC) in 2 layers of 1.5 mm each 3-Hybrid resin (Filtek Supreme Ultra) in 2 layers of 1.5 mm each + etch-and-rinse adhesive (Scotchbond MP) 4- bulk-fill resin (Filtek Bulk Fill) in one layer of 3 mm + etch-and-rinse adhesive (Scotchbond MP)	1- resin composite with nanoceramic fillers onlays (LAVA Ultimate)	PBE did not influence results in terms of margin quality and fracture resistance to a statistically significant level.
Juloski et and al. (18)	14 molars	-Marginal adaptation	1-flowable composite (Premise Flowable) in 2 layers of 1 mm each + etch-and-rinse adhesive (Optibond FL) 2- Bulk-fill flowable composite (Tetric EvoFlow®Bulk Fill) + universal adhesive (Adhese Universal)	1-1-hybrid ceramic CAD/CAM Block overlays (GC Cerasmart)	CMR seems to provide less adequate seal of the margin than the one achieved by cementing the restoration directly to dentin without CMR.
Zhang and al. (19)	80 maxillary premolars	-Marginal adaptation -Fracture resistance	1-Bulk fill resin (SDR) in one layer of 3 mm + self-etch adhesive (Tetric N-Bond) 2-Hybrid resin (Filtek -Z350 XT) in 2 layers of 1.5 mm each + self-etch adhesive (Tetric N-Bond)	1-Lithium disilicate reinforced glass-ceramic endocrowns (IPS e.max CAD)	PBE increases fracture resistance but not microleakage. A higher fracture resistance value was observed in PBE groups regardless of the material used.
Grassi and al. (20)	52 third molars	-Fracture resistance	1- bulk-fill resin (Admira Fusion Flow) + universal adhesive (Futurabond U)	1- Laboratory made composite inlays (Grandio blocs) 2- leucite-reinforced glass-ceramic inlays (IPS Empress CAD)	DME was not negative for fatigue and biomechanical behaviors.
Da Silva and al. (21)	25 third molars	-Bond strength	1-Hybrid resin (Filtek Z250) in 2 layers of 1 mm each + etch-and-rinse adhesive (Adper Scotchbond 1XT)	1- Laboratory made composite inlays (Gradia Indirect)	The proximal box elevation improved the bond strength attained by a self-adhesive resin cement (G-Cem).

3.2. Marginal adaptation

In the current literature review, the most frequently investigated parameter is the marginal adaptation. 13 in vitro studies investigated the influence of CMR on the marginal quality of indirect restorations using various methods. A Scanning electron microscopy at 50× or 200× magnification or a microleakage evaluation by using dye penetration methods were performed. The quality of the marginal adaptation was assessed before and after thermo-mechanical loading.

Results are based on a comparison of the marginal adaptation between an experimental group with deep margin elevation and a control group treated with an indirect restoration bonded directly to the cervical dentin below the cementoenamel junction.

Most of the studies concluded that the interfaces between the luting cement and the CMR material, as well as between the luting cement and the final restoration, should not be a matter of concern for the researchers and clinicians (12,13,18). This could be due to the maximal precision of the CAD/CAM restorations that provided very good fit of the restoration to the supragingival preparation margins (18). A good seal without any imperfections or gaps at this interface could be achieved.

Regarding the interface between CMR material and dentin as well as between the luting cement and dentin, most of the studies supported the fact that no differences existed in marginal quality of the restorations placed directly on dentin following the conventional luting procedure or on composite restorations used for relocation of the cervical margin (5,6,7,8,9,10,11,14,17,22). Adding to that, the incremental technique may positively influence marginal integrity. Careful layering (3 layers) exhibits fewer gaps than no layering (1 layer) (2,8).

However, although fewer, other studies recorded that conventional technique showed superior marginal adaptation compared to CMR technique (12,13,18,19).

3.3. Fracture strength

The samples were subjected to load until failure using a universal testing machine in order to determine the resistance to fracture and the fracture pattern.

A systematic review published in 2019 supported the fact that margin elevation has no impact on the fatigue behavior, fracture resistance, failure pattern, or fracture repairability regardless of the restoration material, the margin elevation material, or the restoration design (23).

Recently, a new finite element analysis method based on a three-dimensional numerical simulation of the clinical situation has been described in the literature to evaluate mechanical strength and stress distribution of the restored tooth. Based on the available evidence, the study investigated that CMR does not significantly affect the strength of the tooth structure (24).

Although, other studies recorded that CMR technique resulted in a higher fracture resistance (14,15,19). In fact, this technique inherently shortens the occluso-gingival height of the indirect restoration that leads to a more favorable stress distribution. According to Vertolli and al. clinicians should consider CMR when the proximal box is greater than 5 mm in order to keep survival rates above 90% for ceramic inlays (15).

3.4. Bond strength

Only one study aimed to evaluate the influence of proximal box elevation on microtensile bond strength of composite inlays to the proximal box floor, using either a total-etch or a self-adhesive resin cement. The results showed that bond strength increased when the proximal cavity floor was elevated with a composite. However, this improvement was significant only when self-adhesive resin cement was used (21).

3.5. Periodontal health

It might be argued that subgingival margins may affect the periodontal health and, therefore, subgingivally located margins should be avoided whenever possible. These recommendations were made in a time when restorative material did not possess adhesive properties, leading to the frequent observation of bacteria in the limits between restoration and tooth. Experimental studies and some clinical reports have shown that the response of the periodontal structures to new restorative materials may be significantly different from those observed when more traditional materials were used (25).

Marco Ferrari and al. carried out scientific research on the influence of the CMR technique on periodontal health, followed by 12-month results of a controlled trial. The main conclusion was that plaque index and gingival index were increased with no statistically significant differences between the different groups. Also, no evident radiographic anomalies of recurrent decay were found. However, higher incidence of Bleeding on probing can be expected around teeth treated with CMR technique (26).

Another clinical study was carried out to investigate the safety and feasibility of CMR of deep carious lesion. The primary and secondary outcomes were pocket depth and residual bleeding on probing after 1 year. Based on this study results, author concluded that CMR procedure do not negatively affect the periodontal health status of patients (27).

Regardless the biological width, a histomorphometry study on dogs was carried out in which a flap was raised on the roots, the bone removed, and a cavity created and filled with composite or glass ionomer. These lead to another kind of biologic width that is healthy, with a longer junctional epithelium along the material, and a smaller connective attachment along the remaining dentin height beneath the composite (28). One must be careful when extrapolating because restorations were placed on the buccal aspect of the roots, where they are easy to fill, polish, and control. More difficulty is experienced in cases of posterior CMR. In fact, it is more difficult for a patient to perform good interdental brushing on posterior teeth presenting a composite margin than on the buccal aspect of anterior teeth (29).

4- Discussion

Cervical margin relocation is considered as a non-invasive alternative aiming to avoid surgical crown lengthening and orthodontic extrusion when it is possible (30). The idea is similar to the conventional open sandwich technique, as the main purpose of both procedures is to facilitate placing the restoration in subgingival cavities by elevating the cervical margin coronally. (31)

CMR presents several benefits concerning avoidance of unnecessary tissue sacrifice, reducing the treatment time by avoiding the healing process. It facilitates the whole adhesive steps of indirect restoration such as optical and conventional impression taking, proper bonding procedures, and excess removal of luting cement. A further advantage of this technique is the immediate dentin sealing which is performed concomitantly with the CMR procedure. Thus, the sealed dentin is protected from bacterial invasion during the provisional phase, and the luting procedure of any definite restoration requires less or no anesthetics at all (32). Additionally, CMR provides smaller restoration size and decreases its depth, which makes the light polymerization process of the luting agents through the indirect restoration easier and more efficient (7).

However, this restorative procedure has some disadvantages. In fact, the additional interface has additive potential for leakage and can lead to treatment failure. Also, the absence of enamel at the cervical margin, which often leaves only dentin and cementum as the main substrates for adhesion, create the weaker area for reliable bonding. Therefore, adhesive bonding to deep cervical dentin could not be considered entirely predictable and safe (22).

The operating procedure establishes the following steps: rigorous isolation of the field with a dental dam, positioning of a matrix, adhesive phase, raising of the cervical margin with adequate material and polishing.

Due to the subgingival extension of the proximal box floor, a matrix with a wooden wedge should be used to achieve isolation for the PBE procedure. Curved matrices are preferable since they provide a better gingival emergence profile and a tight subgingival fit compared to traditional ones. The presence of sufficient tooth substance at both buccal and lingual walls is a prerequisite for the stability of the system. The matrix height should be reduced to 2 or 3 mm, slightly higher than the desired elevation to avoid overfilling the box. No rubber dam or gingival tissue should remain between the cavity margin and the matrix. (38) Finally, the matrix-in-a matrix technique represents the final option in case of an extremely deep and localized lesion. This technique consists of adding a sectional matrix inside the modified circumferential matrix band and then sliding a teflon tape apically between the 2 matrices (3,33).

The choice of the material for CMR is still a controversial issue (34). Resin-modified glass ionomer has a thermal expansion coefficient closest to dentin tissues, a hydrophilic nature, a strong chemical bond to tooth structure via chelation, and a fluoride release. However, despite these advantages, there are several properties that are less ideal including inferior mechanical properties, a less polishable surface as well as higher solubility rates (15). Given these discouraging properties, the authors do not recommend its use.

According to the published reports, microhybrid viscous composite, flowable composite, or a combination of them can be applied. Flowable have a low young's modulus (3.6 to 6.7 GPa) and therefore a higher level of elastic deformation and intrinsic internal flow capacity (1). They are also easily applied to deep proximal areas resulting in fewer voids. However, the use of flowable as the first increment for the cervical step is controversial because of their higher polymerization contraction and lower mechanical properties. So, they should not be used in thick layers, and their thickness should be limited to 1–1.5 mm. If more material is needed, a combination of restorative and flowable composite is recommended (35,36).

On the other hand, when microhybrid or nanohybrid restoratives are indicated, the matrix can be displaced during the placement of a such firmer material, resulting in some difficulties to adapt it into cavities. So, they should be preheated to facilitate placement and minimize the risk of interlayer gaps (22).

Resin composites have undergone significant improvements, but still have some shortcomings, especially polymerization shrinkage. That's why changes in the formulation of the composite have been investigated, with recently developed low-shrinkage resin composites, such as those based on silorane. They consist of a matrix which is formed by the cationic ring-opening polymerization of the silorane monomers. Studies have shown that siloranes exhibit several advantageous properties compared to methacrylate-based resin composites, eg, low polymerization shrinkage (0.94 vol%32), low microleakage, good color stability, and low water absorption and solubility (37).

Regarding the most appropriate adhesive system, when an etch and rinse system is required, selective enamel etching is difficult to achieve without the risk of over-etching the neighboring dentin. A clinical compromise was proposed. It consists of conditioning such thin enamel, together with dentinal tissue, for a limited time of 5 to 10 s. Another approach suggests the use of a 2-step self-etch adhesive system, which skips selective etching of the enamel and implies a promised result (36). Da Silva and al. concluded that none of the adhesives could hermetically sealed the interfaces created in dentin or when subgingival margins were elevated. Furthermore, higher nanoleakage values were determined for the etch and rinse system in comparison with the two-step self-etch adhesive which is considered as the gold standard. (38)

After that, the applied material used to elevate the deep cervical margin should be thoroughly shaped and polished with diamond burs and a variety of polishing devices such as flexible discs of decreasing grit and polishing strips (32).

Before proceeding with the final impression, a bitewing radiograph should be taken to make sure that there are no gaps or overhangs (3). Finally, the rubber dam is removed, and a digital or conventional impression is taken.

The in-vitro investigations analyzed in this review concluded that CMR results in marginal integrities and fracture strength are not different from margins placed directly in dentin. The contribution of margin elevation is therefore not to improve the quality of bonding to the cementum dentin-substrate or the fracture strength but rather to facilitate the operational steps of an indirect restoration.

Another worth investigation is about the periodontium reaction to CMR procedure. It has been suggested that minor violations of limited extent and with small but perfectly adjusted composite surface areas have been assumed to be non-detrimental, in particular in cases of maintained oral hygiene measures (32). DME are compatible with periodontal health, showing a binding capacity of the fibers of epithelial tissue to the surface of resin restorations. These can be explained by the fact that the junctional epithelium is not selective towards surfaces and is shaped by simple juxtaposition of epithelial structures through the hemi-desmosomes on a surface, as long as the surface is hard, smooth and clean. However, connective attachment is very selective (39). No invasion of the connective tissue is tolerated (40).

Regarding the durability of the CMR technique and its impact on restoration performance. Bresser and al. conducted a clinical evaluation of 197 partial indirect restorations with cervical margin relocation in the posterior region for a time of up to 12 years. Authors made a conclusion that indirect restorations with CMR have a satisfactory clinical outcome leading to an overall cumulative survival rate of 95.9% for partial lithium disilicate restorations over a 12-year observation, but longer follow-up is needed (41).

In another retrospective clinical study with follow-up periods ranging from 6 to 21 years, no clinical failure was reported. Indeed, none of the restorations showed recurrent decay or fractures; no restored tooth surveyed underwent any pulpal complication or required any endodontic treatment. However, no attempts were made to evaluate the surrounding tissue response to CMR (42).

Recently, a systematic review was conducted evaluating the clinical performance of indirect restorations with cervical margin relocation. Based on the available evidence, CMR procedure could be associated with low rate of complication in a relatively long term (43). Another recent systematic review examined the survival rate of decayed teeth restored using the crown lengthening technique and compared it to the CMR technique. Authors concluded that CMR has a better survival rate than surgical crown lengthening (31).

5- Conclusion

Based on the reviewed literature, it can be concluded that CMR technique emerged as an interesting non-surgical alternative to surgical crown lengthening.

The available literature is limited mainly to in vitro studies. In vivo studies to support or discourage the clinical use of the DME-technique is lacking. Further research, scientific evidence and randomized clinical trials are needed.

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