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Extended Resin Composite Restorations: Techniques and Procedures

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Clinical Relevance

This article provides an overview of the state of the art of different restorative treatment procedures and techniques needed for placing extended posterior resin composite restorations.

SUMMARY

This article gives an overview of the state of the art of different restorative treatment procedures and techniques needed for placing extended posterior resin composite restorations. Clinical aspects related to the procedure are discussed and reviewed based on the current literature, such as the use of proper adhesive restorative materials, use of liners and bases, moisture control, reconstruction of proximal contacts, extended resin composite restorations, and techniques to address restoring teeth with deep subgingival margins.

INTRODUCTION

Posterior resin composite restorations are now accepted as a reliable, successful, and predictable alternative for direct restoration of posterior teeth.[1-6] Posterior resin restorations offer advantages over traditional amalgam restorations, such as the possibility to use minimally invasive intervention, the ability to bond to the remaining tooth tissues, and the ability to predictably repair defective restorations intraorally.[7] The survival of posterior resin composite restorations is good, and based on reviews it can be concluded that mean annual failure rates vary between 1% and 3%[3,8] and that the main reason for failure for direct resin restorations is (secondary) caries and fracture of the restoration or tooth.[2,5,6,9] In a recently published meta-analysis[10] including 12 longitudinal studies of direct posterior resin composite restorations with at least five years' follow-up, the effects of individual variables (such as patient-, material-, and tooth-related variables) on the survival of posterior resin composite restorations were investigated. It was found that annual failure rates for posterior composite restorations after five and 10 years were 1.8% and 2.4%, respectively, which matches the rates identified in the earlier-mentioned reports. Moreover, the authors found that the individual caries risk and number of restored surfaces play a significant role in restoration survival. Posterior resin composite restorations in patients with a medium or high caries risk had a three times higher risk for failure compared to

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DOI: 10.2341/15-212-LIT

restorations in the low–caries risk patients. Regarding the number of restored surfaces, each additional surface led to an increased risk of failure of 30% to 40%. Another individual risk factor that also has a statistically significant effect on the annual failure rate is bruxism,[11] which may increase the risk of failure by up to four times.

The indication for posterior resin composite in the late 1990s was restricted to small occlusal and occlusoproximal restorations. Nowadays, even large cusp-replacing resin composite restorations[12] and total rehabilitation with resin composite restorations are performed to treat patients with severe tooth wear.[13,14] In addition, a shift in the teaching of posterior resin composites has taken place. While 90% of dental school curricula did not include any didactic teaching of posterior resin composites in the mid-1980s, this rate dropped to 4% or less in the late 1990s and to 0% in the early 2000s. However, 21% of dental schools still did not teach the placement of resin composites in three-surface cavities in permanent molar teeth as of the late 2000s.[15] Interestingly, the authors[13,14] also found that, in the late 1990s, cavity size was no longer mentioned among the five most common contraindications for posterior resin composite placement, but still there is some concern in relation to placement of resin composites in larger cavities (ie, where the buccolingual width of the cavity exceeds one-half of the intercuspal width of the tooth). Overall, it may be concluded that a much wider range of applications involving use of posterior composite restorations is taught than was the case 10-15 years ago.

As a result of this change, dentists today dare to use resin composite materials even for extended restorations and in more complex situations. The skills of the operators have improved, and dentists have gained confidence in placing resin composite restorations even in extended preparations. Therefore, the purpose of this article is to provide an overview of the state of the art of the different restorative treatment procedures and techniques needed for placing extended posterior resin composite restorations.

Adhesives and Composite

From two randomized clinical trials investigating the clinical success of different adhesive bonding systems (three-step etch-and-rinse adhesives and two-step self-etch adhesive) on noncarious cervical lesions, it was found that a highly acceptable clinical performance was achieved for resin composite restorations. From an eight-year clinical study using a mild two-step self-etch adhesive, Clearfil SE Bond (Kuraray, Osaka, Japan), it was shown that selective phosphoric acid etching of the enamel margins had only some minor positive effect on secondary clinical parameters, such as a lower incidence of small marginal defects/discolorations at the enamel side after clinical functioning.[16] Moreover, from a 13-year clinical study[17] using two three-step etch-and rinse adhesives, marginal defects and discolorations were observed at a steadily growing incidence rate, but most were of only a minor extent, such that did not require urgent restoration repair and certainly no restoration replacement. It may be concluded that even after long-term clinical service, three-step etch-and-rinse adhesives and mild two-step self-etch adhesives will result in a clinically acceptable survival rate.

As already reported, from multiple clinical studies, the mean annual failure rate of hybrid resin composite materials in posterior restorations is between 1% and 3%. However, there is little evidence that the varying material properties of the resin composite are a relevant factor in restoration longevity.[18,19] As survival of restorations is mainly dependent on other factors related to the individual patient and operator, improvement in the success of resin composite restorations may indicate that prevention and a conservative approach toward restoration replacement should have higher priority than the material used.

Liners and Bases

For deep preparations, a liner or base of glass ionomer is often placed as a standard procedure for protection of the pulp. A liner or base can be placed in two ways—in an open or a closed sandwich restoration. In a closed sandwich restoration, the dentin is fully covered with a glass ionomer liner but without extending it to the external cavosurface margin. In an open sandwich restoration, the cervical cavosurface margin of only the proximal box is restored with a restorative glass ionomer (Figure 1a-d). The reason for which one uses a liner or base, with a lower modulus of elasticity compared to resin composite (such as glass ionomer or calcium hydroxide), is the stress-absorbing effects of the layer, which could absorb and compensate for polymerization shrinkage stresses and result in less postoperative sensitivity.[20] However, the effect of glass ionomer liners on postoperative sensitivity is equivocal. One study[21] found no statistically significant difference in postoperative sensitivity between the restorative procedures with or without the glass

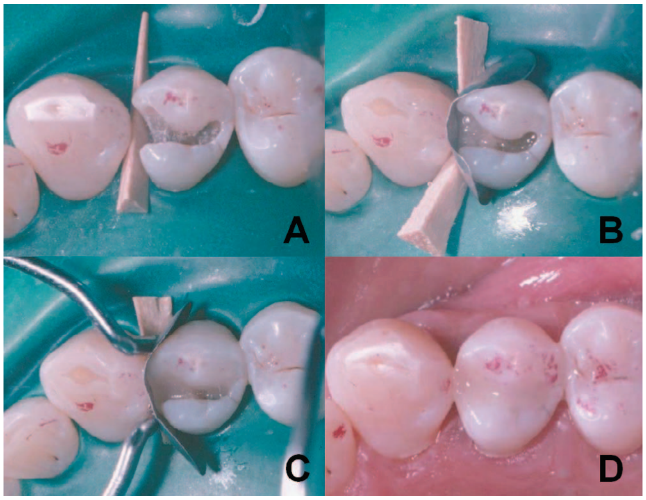

Figure 1. *Open sandwich restoration. (a) MO amalgam with recurrent caries removed. Gingival margin is entirely in dentin. (b) After conditioning of the prepared dentin surfaces, a restorative resin-modified glass ionomer (RMGI) is injected as the first increment into the mesial proximal box. A thin layer of RMGI is also placed as a liner on the pulpal floor. As a result of the lessened abrasion resistance of RMGI compared to composite, the RMGI increment should be maintained apical to the proximal contact so that the contact area is restored with resin composite. (c) Following etching and placement of a three-step etch-and-rinse adhesive on the RMGI and remaining cavity walls, an initial ramped increment of resin composite is placed and cured. (d) Finished restoration.*

ionomer liner, regardless of the adhesive used, while another[22] found that a glass ionomer liner did significantly reduce short-term postoperative sensitivity. In general, postoperative sensitivity in posterior composites is infrequent and tends not to be a substantial problem.[8]

Two studies[1,23] found that restorations placed with a glass ionomer or calcium hydroxide base resulted in an increased risk of failure of the resin composite restoration compared to restorations without a base. However, a recent meta-analysis[10] of 12 studies found no difference in the risk for failure in restorations with or without a liner once the data from a single-practice, retrospective study were excluded from analysis. Likewise, another long-term clinical study[19] found no effect on survival of the resin composite restorations. However, they did find a significant effect on the failure mode of restorations in which a glass ionomer base was placed, as those restorations presented more failures due to fractures. In contrast, a six-year clinical study[24] of extensive Class II open sandwich resin composite restorations demonstrated no difference in restoration failure due to caries vs material fracture.

Against the concern regarding the potential for increased fracture of lined posterior composite restorations must be weighed the potential benefit of enhanced margin integrity with the use of a glass ionomer increment at the dentin gingival margin, particularly in high–caries risk patients. A clinical trial[25] revealed that recurrent caries in Class II composites is eight times more likely adjacent to the gingival margin vs the occlusal margin. Multiple studies[1,2,8,10] have demonstrated caries to be the most common cause of restoration failure, along with fracture. Glass ionomer has repeatedly demonstrated the best marginal adaptation and lowest *in vitro* leakage compared to bonded composite in all cavity classes.[26-29] A relationship between the occurrence of secondary caries and the presence of a glass ionomer base beneath a resin composite restoration could not be proved in two studies.[4,19] In a three-year study[30] of 274 mostly extensive Class II open sandwich restorations in which 43% of the patients were considered caries-risk individuals, only one restoration showed recurrent caries. In this study, two main groups of open sandwich restorations, differing from one another in the thickness of the layer that was placed, were evaluated. In addition, a six-year clinical study[24] of extensive Class II open sandwich composite restorations showed good clinical results, with an annual failure rate of 3%. Unfortunately, in both studies no adhesively placed resin composite restorations absent the use of liner were included, so the relationship between (secondary) caries and the presence of a liner could not be shown in these studies. A three-year study[31] that directly compared the performance of Class II composites restored with either an adhesive-only technique or an open sandwich technique showed equal restoration performance, except for significantly reduced gingival margin demineralization in the open sandwich group.

A possible explanation for the suggestion that the use of a glass ionomer liner or base could result in increased restoration fractures could be the difference in mechanical properties (eg, modulus of elasticity) between the base (calcium hydroxide or glass ionomer) and resin composite materials. This may result in more fatigue of the resin composite restoration and, therefore, in more fractures. Further investigations are needed to study this hypothesis and to shed more insight onto the effect of the individual patient risk factors, such as bruxism and caries risk. Moreover, it is unknown whether the thickness and type of glass ionomer or calcium hydroxide base plays a role in the failure behavior.

Furthermore, as noted above, a liner of glass ionomer would be beneficial in the reduction of secondary caries because of the presence of fluoride in this material.

MARGINAL ADAPTATION

Obtaining a good cervical cavomargin adaptation of the restoration to the tooth can sometimes be a clinical challenge. Since voids or openings at the margin might result in secondary caries, good adaptation is indispensable.[32] It can sometimes be more difficult to restore a smaller cavity than a larger one. A known technique to fill a preparation is to use a combination of two different viscosities of resin composite. As a first step, a flowable base is placed and polymerized, and secondly, a more viscous resin composite material is placed. When using a high viscous resin composite 'packable' material, it was shown[33] that using an initial increment with a flowable composite reduced the number of porosities at the cervical margin. A modification to this technique is the "snowplow" technique.[34] After inserting a small amount of flowable resin composite in the box, the material is not separately cured, after which the more viscous hybrid composite is inserted into the cavity. Laboratory data indicate that the snowplow technique reduces gingival leakage[35,36] and void formation[34] compared to placing and curing separate layers of flowable followed by viscous composite. During insertion of the resin composite, the flowable composite is pressed against the cavity walls and will be partly pressed out of the cavity. In an *in vitro* assessment of different fill techniques, the use of flowable composite always led to higher percentages of marginal overhangs in bevelled Class II restorations compared to fill techniques using more viscous composites.[37] Therefore, in the process of placing resin composite restorations the use of wedges is indispensable. A proper placement of the wedge will result in a controlled and dry working field, and above all it will provide a good adaptation of the matrix to the cervical area of the tooth and prevent gap formation.

MOISTURE CONTROL

Moisture control is an important prerequisite in order to avoid contamination of the acid-etched surface of the preparation with saliva or blood. It can be obtained with rubber dam or with cotton rolls in combination with aspiration by a saliva ejector. In numerous situations, rubber dam may provide an ideal dry operative field during the whole restorative procedure. However, in some complex clinical situations, rubber dam might even hamper the placement of a restoration and therefore cannot always be used. After reviewing the outcomes of several individual studies comparing the clinical performance of posterior composites placed with and without rubber dam isolation, no clear conclusion can be given. Most studies[23,38-41] reported no statistically significant differences in survival rates or clinical behavior of resin composite restorations placed with cotton rolls and proper aspiration or with rubber dam. On the contrary, a meta-analysis[8] on direct posterior composite restorations found that restorations placed with rubber dam showed fewer material fractures, and this also significantly enhanced overall longevity. A recent meta-analysis[42] found similar findings with Class V restorations, in which resin composites placed with rubber dam isolation demonstrated significantly less restoration loss and marginal discoloration compared to those placed without rubber dam. It might be concluded that the use of rubber dam is not a goal in itself, as the main aim is to obtain a controlled dry working field, but it seems that the use of rubber dam may be the best way to achieve moisture control.

PROXIMAL CONTACT RECONSTRUCTION

The literature provides no clear definition on how tight a contact should be in order for one to consider it to be 'normal.' In most studies contact tightness is qualitatively evaluated by the resistance in passing dental floss through the proximal contact, resulting in the qualifications 'open,' 'weak,' or 'strong.'[43] The intra- as well as the inter-individual variability is very large, and therefore it is not possible to define the 'normal' proximal contact tightness in a quantitative way.[44] To obtain a tight proximal contact with Class II resin composite restorations, the clinical procedure has to compensate for the thickness of the matrix as well as the polymerization shrinkage of the resin composite. One of the techniques recommended to achieve a tight proximal contact with resin composite restorations is the 'pre-wedging' or 'multiple wedging' technique.[45] A wooden wedge is firmly pressed into the interdental space before cavity preparation and is kept in place during preparation. When the restoration is placed, pressure with a hand instrument can also be applied on the inside of the matrix band against the adjacent tooth surface while one is polymerizing the first layer. However, compared to the use of separation rings, the separation obtained with the single insertion pre-wedging technique is negligible.[46] This was also confirmed in several clinical studies[44,47,48] showing that regardless of the type of

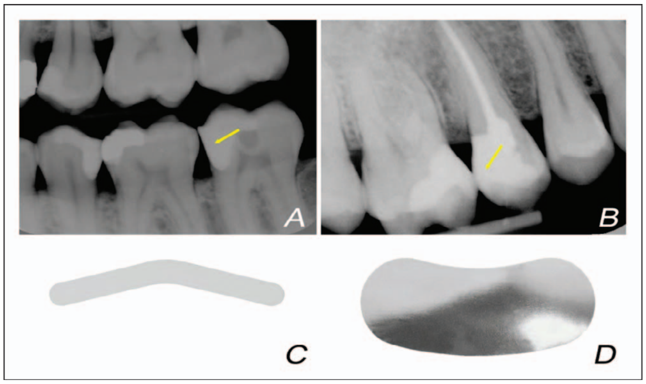

Figure 2. *The use of a flat circumferential matrix may lead to abnormally small or enlarged interproximal areas that are more prone to food impaction. Pre-contoured (sectional) matrix bands may be advantageous, as they result in more anatomically shaped interproximal contours.*

matrix involved, use of separation rings in the reconstruction of proximal contacts of Class II resin composite restorations resulted in significantly tighter and more reliable proximal contacts. Separation can also be significantly enhanced with a multiple wedging technique in which pressure is reapplied to the wedge after initial insertion.[49] Regardless of the pre-wedging technique utilized, wedges also apically displace the interproximal papilla and rubber dam, protecting the gingival tissues and minimizing blood in the operative field. In addition, wedges are still indispensable to obtain a proper cervical adaptation of the matrix to the tooth.

Interestingly, it was also found[50] that the proximal contacts of posterior resin composite restorations were stronger than before treatment began, although this effect tended to diminish after a six-month period, even though the contacts remained tighter than before treatment. Moreover, it was found that those proximal contacts that were weaker than before treatment remained almost unchanged after a six-month period.

In addition to the tightness of the contact, the shape of the proximal contour may also be regarded as an important clinical factor. Use of flat matrix bands without pre-contour will result in abnormal small or enlarged interproximal areas that are more prone to food impaction (Figure 2). Therefore, pre-contoured matrix bands may be advantageous, as they have also been shown[51] to result in improved strength of the marginal ridge of Class II restorations compared to the flat proximal shape.

For 'standard' two- (MO/DO) or three- (MOD) surface restorations, sectional matrix bands in combination with separation rings are the first choice (Figure 3). However, in cases in which the preparation is more extended to the buccal or palatal side, it becomes more difficult to place the sectional matrix bands and separation rings. A possible solution is to divide the restorative procedure into two separate steps using different matrix systems aiming to simplify the cavity design to a standard MO/DO/MOD-cavity design. When the preparation is extended to the buccal or palatal side of the tooth, first a circumferential matrix can be placed to obtain a proper cervical adaptation, allowing application of the adhesive, and to place the resin composite at the buccal or palatal side, without restoring the proximal areas. Now that the preparation is simplified, sectional matrices with separation rings can be placed, after which the restoration is finished.

Preparations with the cervical cavomargin below the cementoenamel junction also present a complex situation. With standard matrix bands (circumferential and sectional) a limited depth can be reached in the cervical area, resulting in an inadequate adaptation of the matrix band to the cervical cavomargin. The use of special matrices may facilitate the restoration of these complex situations, and special matrix bands are available with cervical extensions (eg, Tofflemire matrix band #2 [Produits Dentaire SA, Vevey, Switzerland] or Contact Matrix Subgingival matrices [Danville Materials, San Ramon, CA]). An alternative is the use of the curved matrix (Greater Curve Tofflemire Bands, OH), which enables a good adaptation in the deep cervical areas. After placement of the deepest part of the restoration, this matrix is removed, and a 'standard' matrix band (circumferential or sectional) is placed to finish the second part of the resin composite restoration (Figure 4).

Another option to obtain controlled access to extended and subgingival preparations is a "mini-flap" to provide gingival retraction adjacent to deep cervical areas (Figure 5).[52,53] A mini-flap, so designated because the incision is limited in extent and is typically confined to keratinized tissue, and normally includes a facial and/or lingual marginal incision that extends mesially and distally beyond the area requiring improved access. If needed, vertical releasing incisions can be made to improve tissue retraction while preventing tearing of the gingival tissues. If the incisions do not extend beyond the mucogingival junction, the tissues can usually be replaced without the need for sutures.

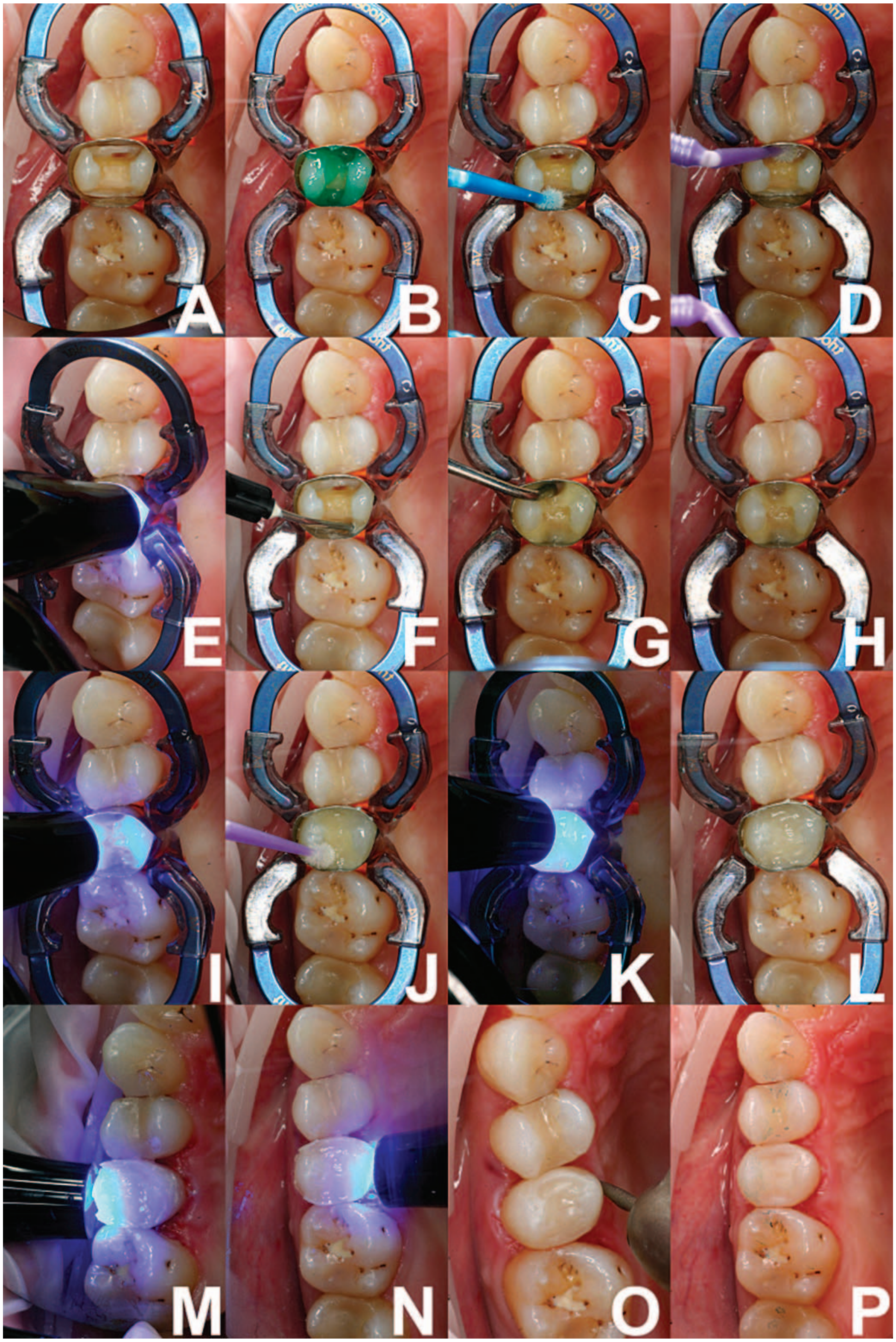

Figure 3. *Procedure of a MOD resin composite restoration using sectional matrices (Contact Matrix System, Danville Materials, San Ramon, CA, USA) in combination with separation rings (V4-Ring Triodent, Katikati, New Zealand). The procedure included a three-step etch-and-rinse technique (Clearfil SA Primer & Photo Bond, Kuraray, Osaka, Japan) and the incremental placement technique of resin composite material (Clearfil Majesty Flow and Clearfil AP-X) using the snowplow technique.*

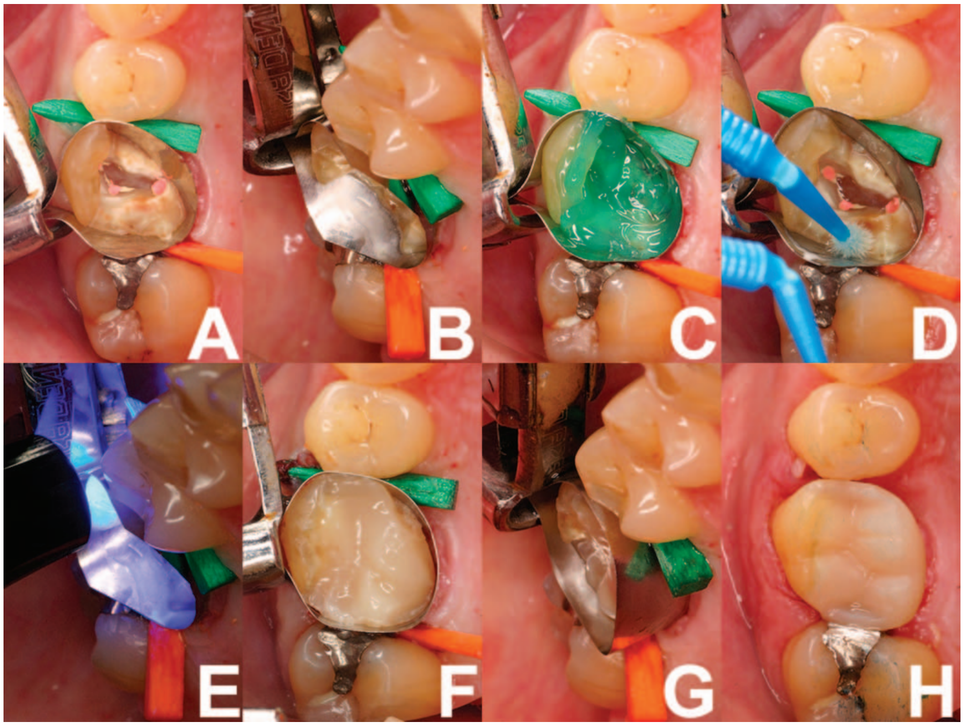

Figure 4. *After preparation, a subgingivally located cavomargin remained. It was decided to restore this preparation in two steps: First, the matrix (Greater Curve Tofflemire Band) secured with wooden wedges was placed. The adhesive procedure was performed, after which the increments of resin composite were applied in the deepest part of the palatal side of the preparation. To obtain an optimal contour of the restoration, the matrix was removed and replaced by a pre-contoured circumferential matrix (Hawe Neos 1001-c, KerrHawe SA, Bioggio, Switzerland). As contamination occurred, the whole adhesive procedure was repeated, and after application of the adhesive the resin composite was applied incrementally and cured. Finally, the restoration was finished and polished.*

DEEP MARGIN ELEVATION

Preferably, cavity margins are located supragingivally, with the margins above the cementoenamel junction (CEJ), but in case of a subgingivally located cavity margin below the CEJ or fractured cusps, traditional techniques are inadequate and are not always applicable. A technique that can be used to facilitate moisture control in these complicated situations is the Deep Margin Elevation or Proximal Box Elevation,[54-56] which offers the possibility of reconstructing step-wise deep proximal margins in order to relocate the cavity margin. The first step is to relocate the cavity margin coronally, after which, in the second step, an indirect restoration can be placed. After relocation of the cervical margin, moisture control is obtained with rubber dam and a controlled placement procedure of an indirect ce-

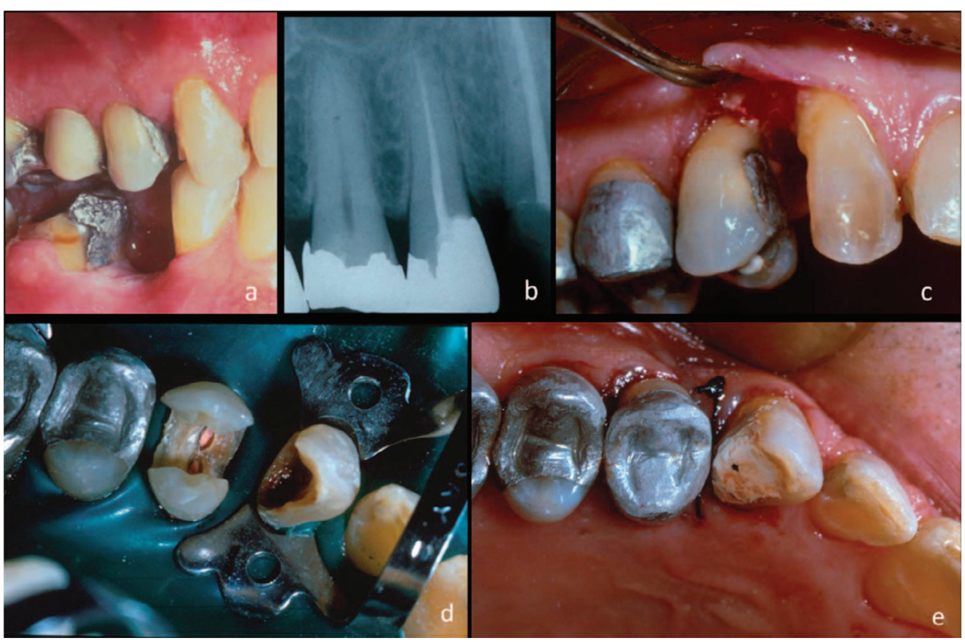

Figure 5. *Mini-flap: (a) Preoperative photo showing tooth #5 MOD amalgam restoration with a deep mesial subgingival margin. Temporary restoration in occlusal surface is where endodontic access was prepared. (b) Radiograph of tooth #5 shows successful endodontic treatment. Mesial margin approximates osseous crest. (c) Facial-lingual mini-flap. Tissue retraction is limited to the keratinized tissue but provides excellent access to mesial restoration margin. (d) Operative field isolated with rubber dam. Note that despite location of deep mesial margin and execution of mini-flap the rubber dam provides complete isolation and accessibility of what once was the deep subgingival margin. (e) Amalgam build-up completed; single suture placed in interdental papilla.*

ramic or resin composite restoration is possible.[57] However, there is some *in vitro* evidence that the proximal box elevation technique may lead to increased gap formation compared to luting the restoration directly to the dentin.[55] Moreover, because of the location and tooth/root morphology of defects requiring consideration for deep margin elevation, moisture control may be difficult or impossible to achieve so as to avoid contamination during bonding procedures. In addition, the reader must be cautioned that there are no clinical studies of even minimal duration demonstrating the viability of this technique.

CLINICAL RECOMMENDATIONS

In the clinical procedure of an extended posterior resin composite restoration, some clinical recommendations may be given:

- Obtain a proper control over the working field by using, ideally, a rubber dam, or if that is not possible, by using cotton rolls with a saliva ejector.
- Use 'gold standard' materials for the adhesive procedure and composite material.
- Sectional matrices in combination with separation rings are the key to success for proximal contact reconstruction in a Class II resin composite restoration.
- Simplify complex and extended cavities into standard cavity design by making use of multiple circumferential and sectional matrix systems.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

(Accepted 8 August 2015)

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