Bonded indirect restorations for posterior teeth: From cavity preparation to provisionalization

Giovanni Tommaso Rocca, Dr Med Dent[1]/Ivo Krejci, Prof Dr Med Dent[2]

Classic bonded indirect ceramic or resin composite restorations necessitate at least 2 appointments. The present article describes an updated technique for the first appointment comprising cavity preparation, dentin sealing, impression, and provisionalization. Two clinical cases are presented to illustrate the procedures step by step. *(Quintessence Int 2007;38:371–379)*

Key words: adhesive sealing, esthetics, indirect restorations

Currently, *conditioning*, *priming*, and *bonding* are the key words in many fields of restorative dentistry. While in previous years cavity design was dictated by material properties and by the necessity of macroretention, today's restorative goal is minimal invasiveness based on adhesion.[1]

The evolution of resin composite materials has enormously improved their esthetic aspect, introducing the postamalgam age,[2] where operators' strategies have completely changed (Table 1 and Fig 1). Direct adhesive resin composite restorations are becoming standard in intracoronal cavities. Bonded indirect onlays fabricated with ceramic or resin composite are increasingly replacing gold and porcelain-fused-to-metal (PFM) crowns in large defects. Main reasons for this change of paradigm are better esthetics, lower costs, and, above all, a more conservative approach. As an example, for a mesio-occluso-distal onlay preparation in a maxillary first molar, almost 50% less tooth structure removal is necessary compared to that for a PFM crown preparation.[3] Moreover, this modern, esthetic restorative concept has proved to have excellent clinical longevity.[4]

While Cerec (Sirona) and immediate direct inlays and onlays may be performed within 1 appointment, the traditional indirect technique used by many practitioners requires at least 2 appointments. Both restorative phases are crucial for an optimal result. Since the introduction of bonded indirect restorations,[5] the protocol has changed to incorporate the adhesive philosophy and improvements in materials and techniques.[6]

The aim of this article is to describe an updated technique for bonded indirect restorations manufactured with resin composite or ceramics and to explain this technique step by step for 2 clinical cases.

[1]Assistant, Division of Cariology and Endodontology, School of Dental Medicine, University of Geneva, Geneva, Switzerland.

[2]Professor and Chairman, Division of Cariology and Endodontology, School of Dental Medicine, University of Geneva, Geneva, Switzerland.

Reprint requests: Dr G. T. Rocca, Division of Cariology and Endodontology, School of Dental Medicine, rue Barthélemy-Menn 19, CH-1205 Geneva, Switzerland. E-mail: Giovanni.Rocca@medecine.unige.ch

Table 1 Suggested restorative techniques according to cavity design and size

Cavity design	Cavity volume	Technique	Material
Class 1		Direct restoration	Resin composite
Class 2 MO/OD	Small	Direct restoration	Resin composite
	Large	Direct restoration	Resin composite
		Workpiece*	Resin composite/ceramic
Class 2 MOD	Small	Direct restoration	Resin composite
	Large	Direct restoration	Resin composite
		Workpiece*	Resin composite/ceramic
Cusp coverage		Workpiece*	Resin composite/ceramic

(M) Mesial; (O) occlusal; (D) distal.
*The different techniques of workpiece fabrication are summarized in Fig 1.

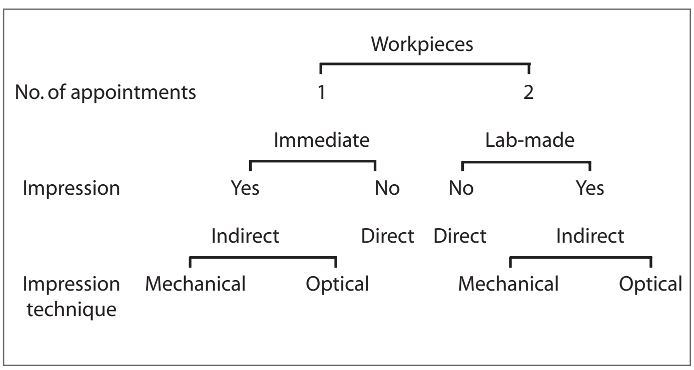


Fig 1 Classification of adhesive workpieces.

1. Apply local anesthesia.
2. Choose tooth shade.
3. Check occlusion with a contact-point paper.
4. Remove old restoration and excavate caries without finishing the cavity margins (see Figs 3a and 3b).
5. Check interocclusal space in centric relation and lateral movements.
6. Place rubber dam.
7. Seal entire dentin surface with a self-etching system, according to the manufacturer's instructions. This procedure also involves thin subgingival enamel margins, if present (see Figs 3c and 3d).
8. Light cure bonding resin.
9. Apply a thin layer of microhybrid resin composite to cover all dentin, fill the retentions, and relocate cervical margins supragingivally if necessary.
10. Light cure composite.
11. Finish enamel margins with fine diamond instruments without exposing dentin.
12. Remove rubber dam.
13. Make impression with silicone or polyether impression material.
14. Insulate cavity with a layer-forming glycerin gel.
15. Insert a nonluted provisional soft resin-based material and light cure it.
16. Check occlusal contacts.

Fig 2 Step-by-step clinical protocol of the modified technique described in this study.

CLINICAL PROCEDURE

The first appointment involves 4 principal steps: cavity preparation, cavity sealing, impression, and provisionalization (Figs 2 to 5).

First of all, the occlusion is checked with contact-point paper because a restoration's margins, being the weakest link of the system, should be placed out of occlusal contacts.

Cavity preparation must be as conservative as possible. The old restoration is removed and caries excavated without finishing the margins in enamel (Figs 4b and 5b). Oscillating, selectively coated diamond instruments (ie, Piezon Cavity System, EMS; or Sonic Sys, KaVo) may facilitate the preparation of the cavity in the interproximal area (Figs 4c to 4e).

Because metallic and provisional restorations, as well as caries, may modify dentin and enamel shades, tooth shade should be chosen either before preparation and caries excavation using a neighboring tooth or after preparation using the tooth itself, but, in any case, before the application of rubber dam.

In the case of an overlay, when cusps need to be restored, interocclusal space in centric relation and in lateral movements is checked before rubber dam application. In general, at least 1 mm for resin composite and 2 mm for ceramic are recommended.

To facilitate adhesive techniques, placing rubber dam is mandatory.[7] In the case of subgingival margins, the placement of a metallic matrix and interproximal wedges will displace the rubber dam from deeper margins, making its application easier (Fig 4f).

Fig 3a Maxillary right first molar with a large amalgam restoration.

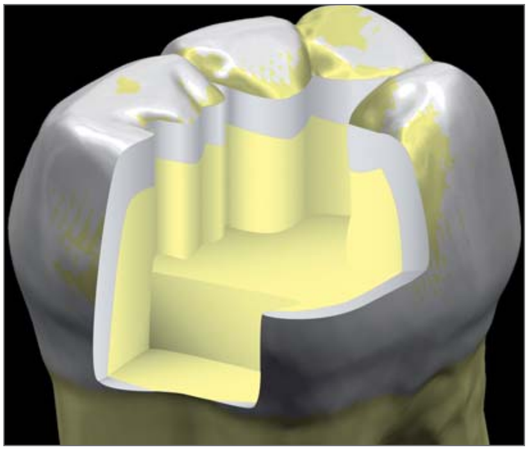


Fig 3b Schematic representation of the cavity after amalgam removal. Note the thin subgingival enamel margins in the mesial box.

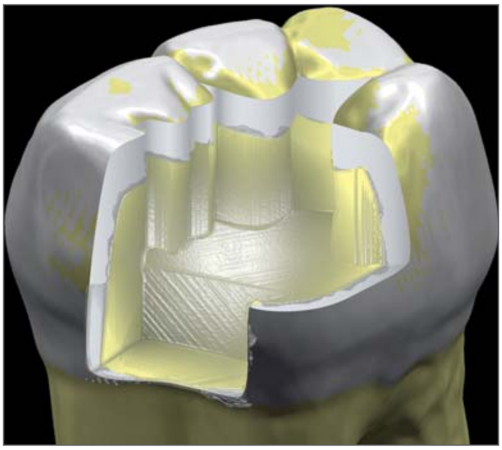


Fig 3c Application of a self-etching primer on dentin and thin subgingival enamel.

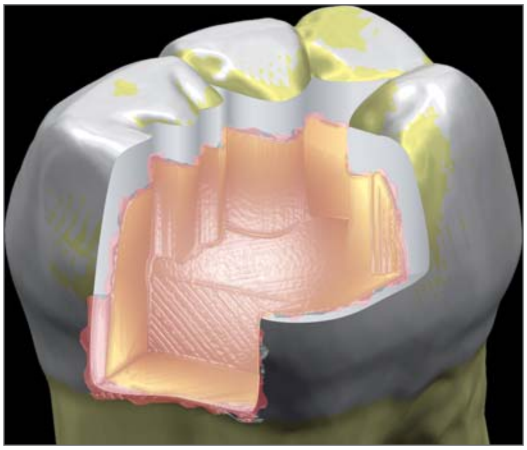


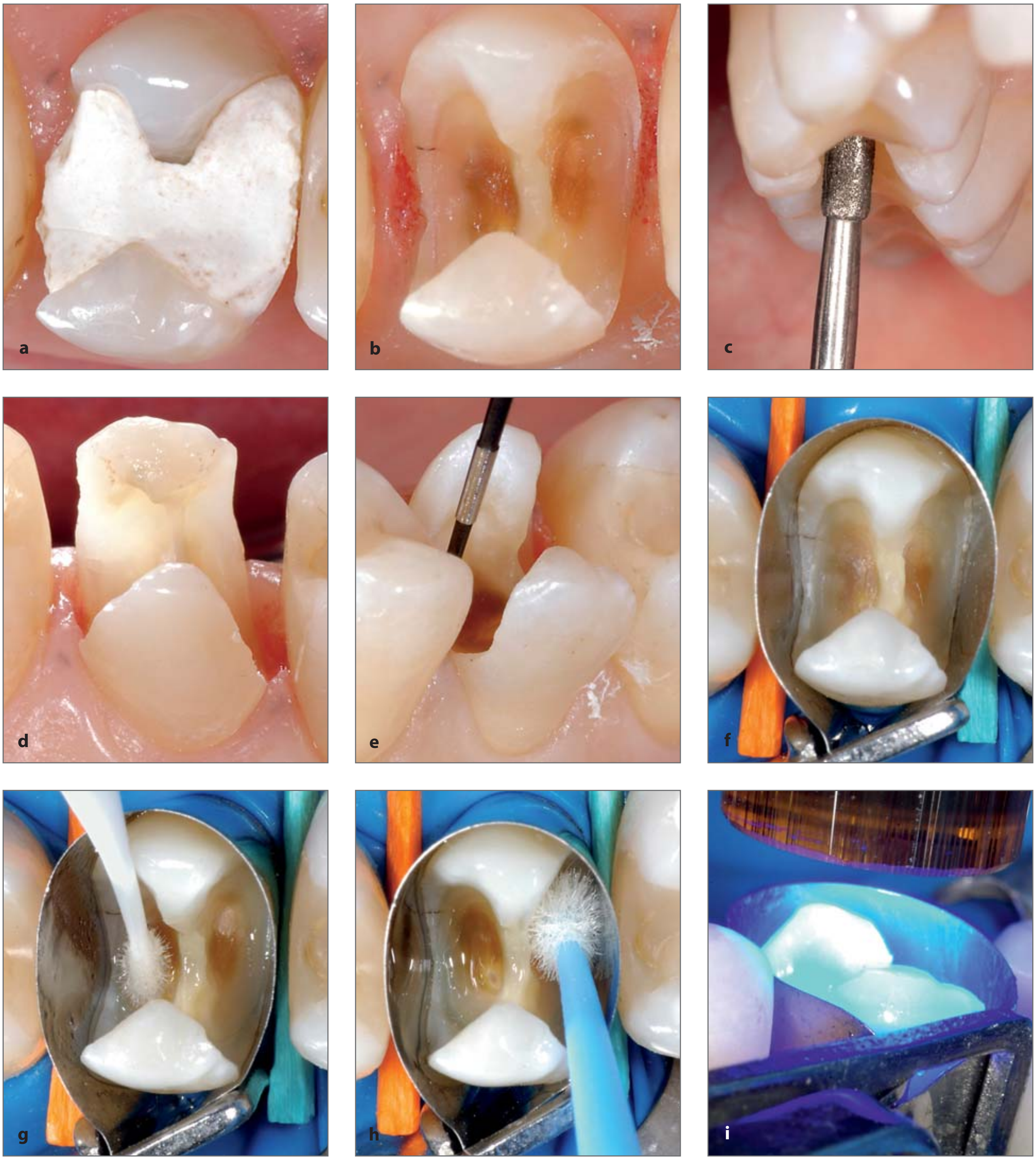
Fig 3d Subsequent application of the bonding resin, followed by the application of a thin layer of resin composite on dentin and subgingival margins.

Once the cavity is properly isolated, a self-etch adhesive system (ie, Syntac Classic, Ivoclar Vivadent) is applied to cover the entire cavity dentin, according to the manufacturer's instructions. When cavity margins are slightly subgingival, typically in mesial and distal boxes, this procedure also involves the thin subgingival portions of enamel margins, if present (Figs 4g to 4i, 5c, and 5d).

In the next step a thin resin composite layer is applied on dentin. The goal is to cover all dentin and the thin cervical enamel, if present, and to achieve an ideal geometry of the cavity: correct taper, minimal undercuts, cervical margins relocated supragingivally, and adequate interocclusal space.[6] For that purpose, a dentin shade of a microhybrid resin composite that exhibits minimal shrinkage is suitable (Fig 4j).

Once the resin composite is light cured for 20 seconds per curing area with a high-power light-emitting diode (LED) light-curing unit (Fig 4k), finishing the enamel margins with fine diamond instruments is the last step before making the impression. It is well known that a beveled margin with enamel prisms cut perpendicular to their long axis is more favorable for marginal adaptation than a butt-joint margin (Figs 4l, 4m, and 5e).[8] If during enamel finishing the dentin is accidentally touched and exposed, adhesion and resin composite application must be repeated.

After rubber dam removal, an impression is made with a silicone or polyether impres-


a
b
c
d
e
f
g
h
i

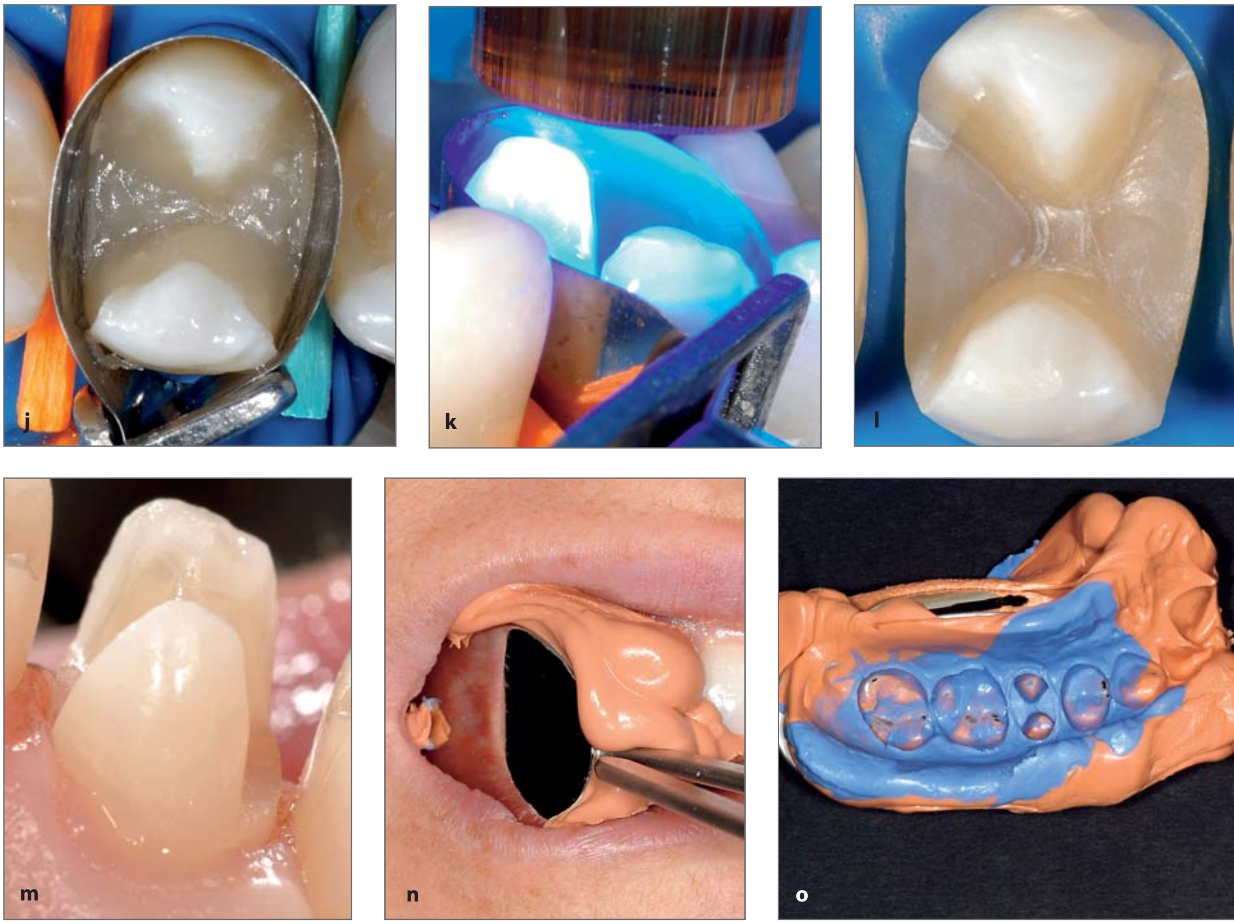


Fig 4a Initial view of a maxillary right second premolar with a provisional restoration.

Fig 4b Cavity preparation: The old restoration is removed, and caries is excavated as conservatively as possible.

Fig 4c Cavity preparation: Oscillating, selectively coated diamond instruments may be used for the finishing of the interproximal zone.

Fig 4d Cavity preparation: Weak cavity walls will be reinforced during composite buildup.

Fig 4e Cavity preparation: If cavity margins are largely subgingival, a crown-lengthening procedure must be planned.

Fig 4f Rubber dam isolation: This procedure is facilitated by placing a metallic matrix and interproximal wedges, which displace the rubber dam from subgingival margins.

Fig 4g Bonding procedure: Immediate dentin sealing with a self-etching system. This procedure also involves thin sub gingival enamel margins, if present.

Fig 4h Bonding procedure: Excess bonding resin is removed with a fresh applicator, as a thick layer of radiolucent bonding agent compromises secondary caries detection on radiographs.

Fig 4i Bonding procedure: Light polymerization with a powerful LED light curing unit.

Fig 4j Composite buildup: Dentin and thin subgingival enamel margins are systematically covered.

Fig 4k Composite buildup: Light polymerization with a powerful LED light curing unit.

Fig 4l Cavity before impression: An ideal geometry is obtained by finishing with fine diamond instruments.

Fig 4m Cavity before impression: Both subgingival margins were relocated occlusally (see Fig 4d).

Figs 4n and 4o Cavity impression.

sion material (Figs 4n and 4o). The cavity is then isolated with a layer-forming glycerin gel (eg, Insulating gel, Heraeus-Kulzer), and a soft provisional resin composite material (eg, Fermit, Ivoclar Vivadent) is inserted into the cavity and light cured without cementation (Figs 5f and 5g).

DISCUSSION

One of the goals of this technique, based on immediate sealing of dentin with an adhesive resin composite layer covering all cavity dentin, including subgingival margins, is to leave the cavity with only 2 substrates before cementation: ground enamel and resin composite (see Figs 4n and 5e). As mentioned by several authors[9,10,12,13] the placement of an adhesive resin composite layer on dentin immediately after cavity preparation provides several supplementary benefits:

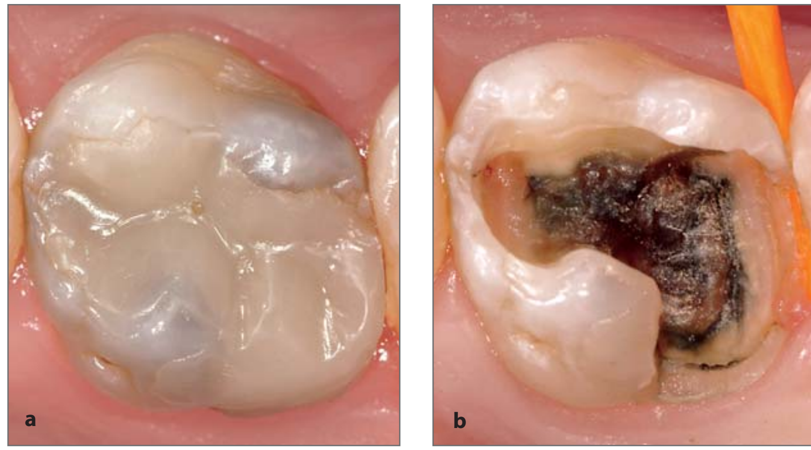
- Perfect cavity sealing. Dentinal tubules are sealed, thus preventing bacterial contamination and dentinal fluid movement. This means increased comfort for the patient during the provisional phase and at the luting appointment. Moreover, cavity sealing allows for the use of nonluted provisional restorations, which are easier to apply and to remove.
- Optimal maturation of dentin adhesion. The adhesion may develop during the provisional phase without being challenged by shrinkage and occlusal loading stresses transferred by the definitive restoration.[10,11]
- No fitting problem of the workpiece during the luting procedure, as the bonding resin is precured on dentin before impression and not during luting.
- Availability of an optimal dentinal substrate. Adhesion is established on freshly cut dentin without contamination by temporary cement.[13,14]
- Separation of dentin (more hydrophilic) and enamel (more hydrophobic) adhesion. During cavity preparation, dentin is immediately sealed, while enamel margins are refinished. During luting, enamel is bonded, while dentin is already sealed and protected.

Once bonding resin has polymerized, a thin layer of resin composite is systematically applied on sealed dentin. Regardless of its composition, this protective layer helps to elevate cavity margins in subgingival areas (addressed later) as well as to eliminate cavity undercuts, thus saving sound tooth structure. Besides these structural functions, the resin composite layer improves the protection of sealed dentin against mechanical and thermal stimuli during the provisional phase, eliminating sensitivity. Moreover, it acts as a physical barrier against mechanical surface treatment during cementation, preserving the integrity of the thin bonding layer.[12] Potential exposure to oral fluids and consequent water sorption of bonding resin during the provisional phase is minimized as well.[15] In addition to the above-mentioned advantages, a resin composite “base” leads to the fabrication of thinner inlays and onlays. That means a better light penetration through the workpiece during light polymerization, facilitating the use of light-cured luting composites for cementation.[16,17]

Several studies have demonstrated that the use of a resin composite as a base under bonded indirect restorations is a promising option.[6,18–20] However, the choice between microhybrid, microfilled, or flowable composite is still controversial.[6,21,22] A highly filled microhybrid composite may be the best choice from different points of view, as flowable composites exhibit high contraction stress during polymerization and may not be sufficiently resistant to deformation under load.[23] In addition, they are difficult to apply precisely, and they may leave excess material in the proximal boxes.[24] Finally, they represent an additional material in the dental office. On the other hand, highly filled microhybrid composites are quite difficult to spread in a thin layer because of their high viscosity. However, this problem may be resolved by the application of preheated material into the cavity; the material is light cured only after cooling to ambient temperature to prevent increased contraction stress at a higher temperature.[25]

Fig 5a Initial view of a maxillary left first molar with an insufficient resin composite restoration.

Fig 5b A distal wedge helps to protect gingiva and the adjacent tooth during removal of the restoration.



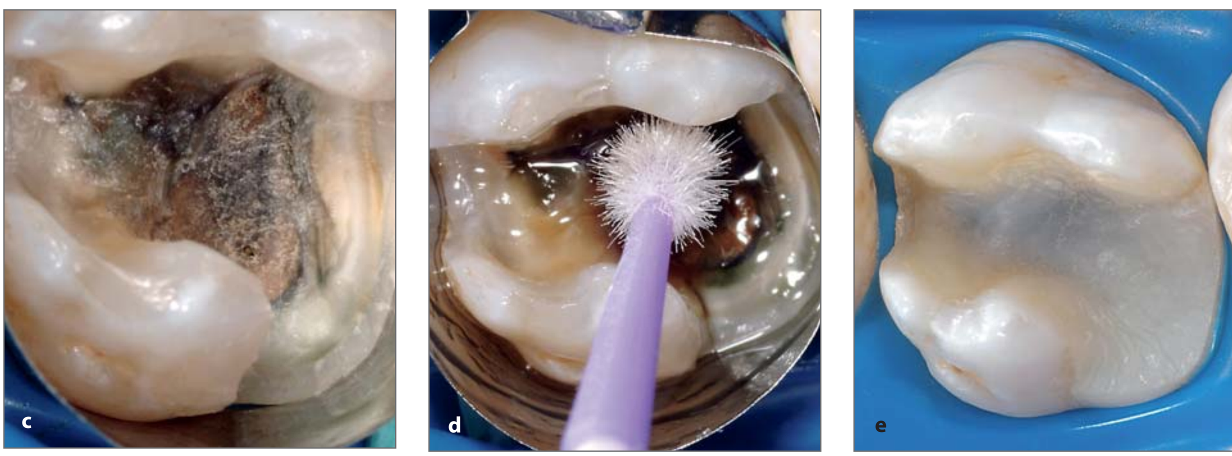
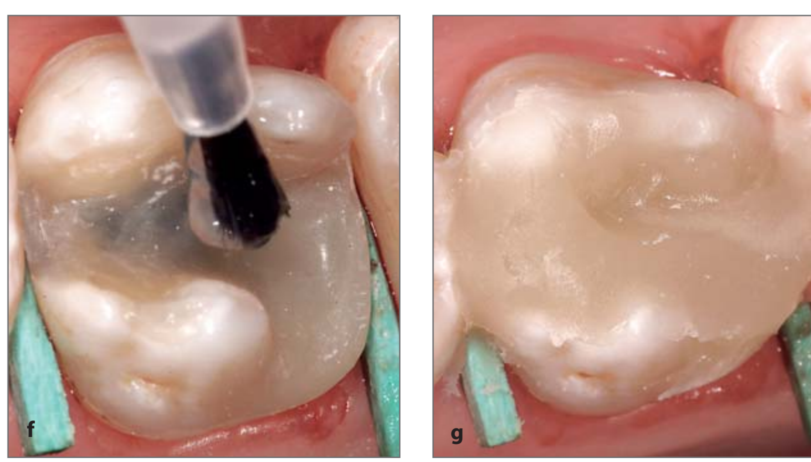


Fig 5c Rubber dam isolation: Enamel is present everywhere around the cavity margins, but it is very thin in the distal box.

Fig 5d Bonding procedure: Immediate dentin and thin subgingival enamel are sealed.

Fig 5e Cavity before impression: Dentin is protected, and the distal subgingival margin is relocated occlusally with an adhesive composite layer.



Figs 5f and 5g Provisionalization: The cavity is insulated with a layer-forming glycerin gel before the application of a soft light-curing resin without cementation. Interproximal wedges minimize bleeding and material overfilling. Soft resin is then polymerized, and correct occlusion is established.

Table 2 Advantages and practical considerations of the modified adhesive luting technique described in this article

Procedure	Advantages	Practical considerations
Adhesive cavity sealing	Perfect cavity sealing during provisionalization	Patient comfort; use of nonluted provisional restorations
	Optimal interval for dentin conditioning	Not possible to overetch dentin
	Bond precuring on dentin and optimal maturation of dentin adhesion	Highest possible bond strengths and no fitting problems of the workpiece
	Adhesion on freshly cut dentin	No dentin contamination with temporary cements
	Separation of dentin (more hydrophilic) and enamel (more hydrophobic) adhesion	Simpler and more reliable adhesion procedures
Resin composite layer	Protection of dentin	Patient comfort
	Elevation of subgingival cavity margins	Easy handling during impression and luting
	Elimination of cavity undercuts	Conservation of sound tooth structure
	Protection of adhesive hybrid layer	Enables safe airborne-particle abrasion of the surface before luting
	Thinner inlay/onlay	Facilitates use of light-cured luting composite

To recreate systematically the proposed cavity configuration, it is important to take precautions with the different thicknesses of enamel. If the enamel is thin and inconveniently located (typically in a subgingival situation), several difficulties arise, such as finishing enamel margins without touching or exposing dentin and injuring gingiva, making an impression, and placing rubber dam during cementation.

In this case, after the cavity is isolated, adhesion to dentin and to the thin subgingival enamel, if present, is established at the same time (see Figs 4g and 5d). For this purpose a self-etching system is recommended because it is easier to handle than a total-etch system and guarantees reliable adhesion to both tissues.[26–28] In fact, the etch-and-rinse technique, based on H_3PO_4 etching, implies the conditioning of dentin and enamel separately, for different intervals. It is evident that in this particular situation, when enamel is thin and inconveniently located, correct conditioning of enamel by H_3PO_4 is difficult without overetching the neighboring dentin. On the other hand, a self-etching primer can effectively condition enamel and dentin at the same time, in a simpler way for the operator. Both tissues are then covered with resin composite, in a way that the cervical margins are relocated supragingivally (see Fig 4m).

Considering the relationship between subgingival restorations and periodontal health, many iatrogenic factors besides the location of margins potentially affect the periodontal tissues, such as the restoration's marginal integrity, surface contouring and polishing, material type and structure, as well as the patient's risk factors (age, smoking, poor oral hygiene, etc). Even though a correlation between these factors and periodontal breakdown was already noted by Black in 1912,[29] there is still a lack of knowledge about the role of each factor in triggering and supporting the pathology.[30,31] However, when restoration margins were well contoured and finished and the patient's oral hygiene was excellent, Paolantonio et al[31] found no clinical changes (accumulation of supragingival plaque, bleeding on probing, and augmentation of probing depth) in periodontal tissues adjacent to subgingival resin composite restorations.

Thus, the proposed modified technique may reconcile predictable, easy handling with minimally invasive preparation, patient comfort, and periodontal health even in restorations with subgingival cavity margins (Table 2).

ACKNOWLEDGMENTS

The authors would like to thank Drs Brazzola Leonard and François Curnier for their technical assistance in the preparation of the schematic drawings.

REFERENCES

1. Ardu S, Perroud R, Krejci I. Extended sealing of interproximal caries lesions. Quintessence Int 2006;37:423–427.
2. Lutz F, Krejci I. Resin composites in the post-amalgam age. Compend Contin Educ Dent 1999;20:1138–1148.
3. Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for posterior teeth. Int J Periodontics Restorative Dent 2002;22:241–249.
4. Manhart J, Chen H, Hamm G, Hickel R. Buonocore memorial lecture. Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition. Oper Dent 2004;29:481–508.
5. Mörmann W. Kompositinlay: Forschungsmodell mit Praxispotential? Quintessenz 1982;33:1891–1900.
6. Dietschi D, Spreafico R. Current clinical concepts for adhesive cementation of tooth-colored posterior restorations. Pract Periodontics Aesthet Dent 1998;10:47–54.
7. Smales RJ. Rubber-dam usage related to restoration quality and survival. Br Dent J 1993;174:330–333.
8. Carvalho RM, Santiago SL, Fernandes CAO, Suh BI, Pashley DH. Effect of prism orientation on tensile strength of enamel. J Adhes Dent 2000;2:252–257.
9. Bertschinger C, Paul SJ, Luthi H, Sharer P. Dual application of dentin bonding agents: Effect on bond strength. Am J Dent 1996;9:115–119.
10. Dietschi D, Herzfeld D. In vitro evaluation of marginal and internal adaptation of class II resin composite restorations after thermal and occlusal stressing. Eur J Oral Sci 1998;106:1033–1042.
11. Dietschi D, Monasevic M, Krejci I, Davidson C. Marginal and internal adaptation of class II restorations after immediate or delayed composite placement. J Dent 2002;30:259–269.
12. Stavridakis MM, Krejci I, Magne P. Immediate dentin sealing of onlay preparations: Thickness of pre-cured dentin bonding agent and effect of surface cleaning. Oper Dent 2005;30:747–757.
13. Magne P, Kim TH, Cascione D, Donovan TE. Immediate dentin sealing improves bond strength of indirect restorations. J Prosthet Dent 2005;94:511–519.
14. Yap AU, Shah KC, Loh ET, Sim SS, Tan CC. Influence of eugenol-containing temporary restorations on bond strength of composite to dentin. Oper Dent 2001;26:556–561.
15. Ito S, Hashimoto M, Wadgaonkar B, Svizero N, Carvalho RM, Yiu C. Effects of resin hydrophilicity on water sorption and changes in modulus of elasticity. Biomaterials 2005;26:6449–6459.
16. Soh MS, Yap AU, Siow KS. The effectiveness of cure of LED and halogen curing lights at varying cavity depths. Oper Dent 2003;28:707–715.
17. Shulte AG, Vockler A, Reinhardt R. Longevity of ceramic inlays and onlays luted with a solely light-curing composite resin. J Dent 2005;33:433–442.
18. Dietschi D, Olsburgh S, Krejci I, Davidson C. In vitro evaluation of marginal and internal adaptation after occlusal stressing of indirect class II composite restorations with different resinous bases. Eur J Oral Sci 2003;111:73–80.
19. Hofmann N, Just N, Haller B, Hugo B, Klaiber B. The effect of glass ionomer cement or composite resin bases on restoration of cuspal stiffness of endodontically treated premolars in vitro. Clin Oral Investig 1998;2:77–83.
20. Krejci I, Boretti R. Resin-based composites for indirect adhesive tooth-colored restorations. [Proceedings of the Academy of Dental Materials, Oct 2001, Siena, Italy.];5:31-36
21. Labella R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. Dent Mater 1999;15:128–137.
22. Stavridakis MM, Dietschi D, Krejci I. Polymerization shrinkage of flowable resin-based restorative materials. Oper Dent 2005;30:118–128.
23. De Munck J, Van Landuyt KL, Coutinho E, et al. Fatigue resistance of dentin/composite interfaces with an additional intermediate elastic layer. Eur J Oral Sci 2005;113:77–82.
24. Frankenberger R, Kramer N, Pelka M, Petshelt A. Internal adaptation and overhang formation of direct Class II resin composite restorations. Clin Oral Investig 1999;3:208–215.
25. Bortolotto T, Krejci I. The effect of temperature on hardness of a light-curing composite [abstract 119]. J Dent Res 2003;82(special issue A).
26. Van Meerbeek B, De Munk J, Yoshida Y, et al. Buonocore memorial lecture. Adhesion to enamel and dentin: Current status and future challenges. Oper Dent 2003;28:215–235.
27. Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: A systematic review of current clinical trials. Dent Mater 2005;21:864–881.
28. De Munck J, Vargas M, Iracki J, et al. One-day bonding effectiveness of new self-etch adhesives to bur-cut enamel and dentin. Oper Dent 2005;30:39–49.
29. Black AD. Preventive treatment of periodontal diseases. Northwest Dent J 1912;10:60–73.
30. Broadbent JM, Williams KB, Thomson WM, Williams SM. Dental restorations: A risk factor for periodontal attachment loss? J Clin Periodontol 2006;33:803–810.
31. Paolantonio M, D'Ercole S, Perinetti G, et al. Clinical and microbiological effects of different restorative materials on the periodontal tissues adjacent to subgingival class V restorations. J Clin Periodontol 2004;31:200–207.