Bonded indirect restorations for posterior teeth: The luting appointment

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Classic bonded indirect restorations are laboratory fabricated and require 2 appointments: one for provisionalization and one for luting. This article describes the adhesive luting procedure, from try-in of the workpiece to finishing and polishing after the adhesive cementation, and it represents the second part of an updated technique for bonded inlays and onlays. The clinical sequence is described step by step with 2 cases. Particular attention is given to the adhesive treatment of the restoration and the cavity as well as the choice of the resin cement. Following the adhesive philosophy and due to improvements in materials and techniques, the simplified approach described may provide predictable luting restoration of the posterior dentition. *(Quintessence Int 2007;38:543–553)*

Key words: adhesive luting, indirect restoration, resin composite

Contemporary luting techniques for bonded indirect restorations are generally based on the adhesive action of a thin layer of resin cement that, once polymerized, bonds tooth-colored laboratory-made restorations to dental tissues, confining polymerization shrinkage stresses to this minimal layer. This procedure, which is simple in principle, is unfortunately complicated by several factors, from the choice of the luting cement to the exact clinical technique to the selection of the best way to mechanically and chemically activate the involved surfaces before bonding.

The purpose of this article, which represents the second part of an updated technique for posterior bonded indirect restorations, is to describe step by step the insertion and luting appointment.

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CLINICAL PROCEDURE

In the first appointment, the tooth cavity was prepared before impression in a way to cover the entire dentin surfaces with a thin resin composite layer, followed by enamel margin finishing. This particular cavity treatment has several practical advantages during cavity preparation, provisionalization, and luting as well.[1]

The second appointment is divided into 6 main steps: *(1)* try-in and shade control of the laboratory-made restoration, *(2)* adhesive treatment of its inner surface, *(3)* adhesive treatment of the cavity surface, *(4)* adhesive luting, *(5)* control and adjustment of the occlusion, and *(6)* finishing/polishing. The clinical protocol is described in Fig 1 and illustrated in Figs 2 to 4.

Marginal adaptation and proximal contacts of the laboratory-made restoration are first checked on the die cast model. Then, the soft provisional resin restoration (eg, Fermit, Ivoclar Vivadent) is removed in 1 piece with an excavator from the tooth cavity, and the fit of the workpiece in the cavity is verified. The better the fit, the easier the removal of excess luting composite, as there will be less danger of tearing the luting composite

1. Check the laboratory-made restoration on the cast: proximal contacts, marginal adaptation, and passive fit.
2. Remove provisional restoration from the cavity with an excavator and try the inlay/onlay in the cavity. Apply an intermediate layer of glycerin to check color. Do not check occlusion (because of the risk of fracture).
3. Apply local anesthesia if needed and place rubber dam.
4. Treat the inner surface of the workpiece according to its composition (see Table 1). Cover the workpiece to protect it from exposure to light.
5. Abrade the entire cavity with 30 or 50 µ Al_2O_3 at a tip distance of about 5 mm.
6. Etch the enamel margins with 35% to 37% H_3PO_4 for 30 seconds, rinse abundantly with water, and dry perfectly with compressed air.
7. Apply silane on the resin composite surface for 1 minute, and dry it with warmed compressed air.
8. Apply a thin layer of hydrophobic light-cured bonding resin on the entire cavity without curing.
9. Cover the cavity completely with preheated light-cured restorative resin composite.
10. Insert the workpiece into the cavity, applying pressure first manually and then with an ultrasonic tip.
11. Completely remove resin composite excesses.
12. Light cure for 5 seconds per area.
13. Light cure for 60 seconds per area and cool tooth intermittently with water spray and compressed air during light curing.
14. Finish restoration's margins with fine diamonds if necessary and repolish with disks or silicone points.
15. Apply transparent fluoride gel for at least 3 minutes and light cure for 5 seconds per surface through the gel to eliminate any remaining oxygen-inhibition layer.
16. Remove rubber dam.
17. Check and adjust occlusion if necessary.

Fig 1 Step-by-step clinical protocol of the luting procedure described in this study.

Table 1 Suggested treatment procedures according to the restoration's composition

Material	Surface treatment
Resin composite (fine hybrid, micro hybrid, nano)	1. Abrasion (30–50 µm Al_2O_3 particles at about 2 bar) 2. Silane (60 s and dry) 3. Light-cured hydrophobic bonding resin (very thin layer, no light precuring)
Ceramics (feldspathic, leucite-reinforced, and lithium disilicate–reinforced)	1. 5% hydrofluoric acid (60 s, wash and dry) 2. Silane (60 s and dry) 3. Light-cured hydrophobic bonding resin (very thin layer, no light precuring)

out of the luting space during excess removal. The esthetic aspect is also checked: Placing the restoration into the cavity with glycerin gel (eg, Insulating gel, Heraeus Kulzer) may help in verifying its chromatic integration (Fig 2a). Considering the practical advantages offered by the indirect laboratory-made technique, only few minimal adjustments of the workpiece are allowed at this moment; otherwise the restoration is sent back to the laboratory for corrections and the luting session is postponed.

The next step involves the adhesive preparation of the workpiece (Figs 2b to 2g and 4a to 4k). Different procedures must be followed according to the restorative material (Table 1). For laboratory-made resin composite restorations, the inner surface is conditioned by airborne-particle abrasion (Figs 2c and 3c). For ceramic restorations, particular care is needed in handling 5% hydrofluoric acid as a conditioner because of its toxicity (Fig 4b). In both types of restoration, organic silane is applied on the conditioned surfaces of the workpiece and, after a 60-second penetration time, it is well dried with oil-free compressed air (Figs 2d, 2e, 4g, and 4h). With certain silanes, hot air used for drying may improve adhesion,[2–5] as it most probably removes the solvent in a more efficient way. Finally, a hydrophobic light-curing bonding resin is applied and not precured. The prepared workpiece is then put under a protective cover (eg, Vivadent Pad, Ivoclar Vivadent) to avoid premature curing of the bond by ambient light (Fig 4k).

Afterward, the operator can proceed to the surface treatment of the cavity (Figs 2h to 2l, 3d, and 3e). As in the first appointment, during cavity preparation, a thin resin composite layer is applied on sealed dentin and subgingival margins, local anesthesia may not be necessary, and rubber dam is easily applied.[1] The authors recommend rubber dam of heavy consistency because its tightness is often better than rubber dam of medium consistency, it is more resistant, and it often does not necessitate dental floss ligatures. The cavity is then gently abraded with 30 to 50 µm Al_2O_3 particles for about 5 seconds at a tip distance of about 5 mm (Figs 2i and 3d). During this phase, the operator's

Fig 2a Try-in of a resin composite laboratory-made restoration on the maxillary right first molar.
Fig 2b Preparation of the workpiece: The indirect resin composite restoration before adhesive treatment.
Fig 2c Preparation of the workpiece: The inner surface is abraded with 30 to 50 µm Al_3O_2 particles.

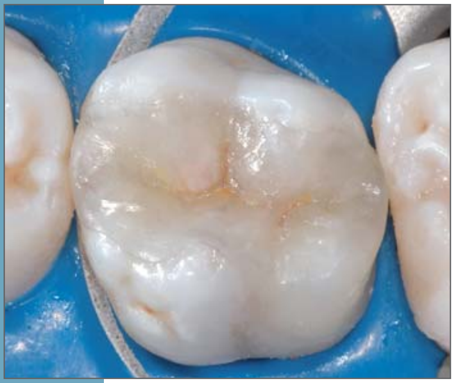
Fig 2d Preparation of the workpiece: The conditioned inner surface is primed with an organic silane.
Fig 2e Preparation of the workpiece: After 60 seconds the silane solution is well dried.
Fig 2f Preparation of the workpiece: Application of hydrophobic light-cured bonding resin.

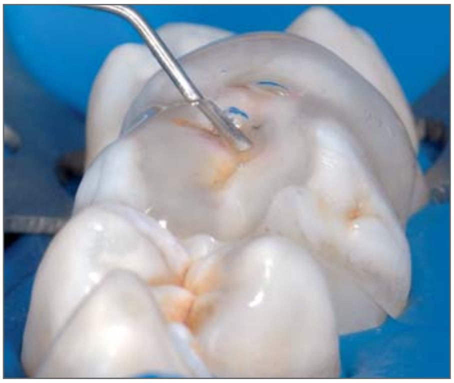
Fig 2g Preparation of the workpiece: Bonding resin is thinned with a gentle blow of compressed air. The restoration is then protected from light to avoid accidental curing by ambient light.
Fig 2h Preparation of the cavity: Occlusal view of the cavity after rubber dam isolation. Only finished enamel margins and resin composite are present in the cavity before surface conditioning.
Fig 2i Conditioning of the cavity: The resin composite layer is airborne-particle abraded.

Fig 2j Conditioning of the cavity: Orthophosphoric acid etching of the enamel margins.
Fig 2k Priming of the cavity: Application of silane coupling agent on resin composite. After 60 seconds, the silane solution is well dried with warmed compressed air.
Fig 2l Bonding of the cavity: A thin layer of light-cured bonding resin is applied on the entire cavity without being precured.

Fig 2m Adhesive luting: A sufficient amount of restorative resin composite is spread onto the entire cavity.
Fig 2n Adhesive luting: The restoration is initially pushed in place manually.
Fig 2o Adhesive luting: The restoration is finally seated with ultrasonic energy. No more than 1-second repeated applications are recommended throughout the occlusal surface to avoid overheating.

Fig 2p Adhesive luting: Excess luting composite is removed with a probe, and the restoration is always fixed in place by a ball-shaped plugger.
Fig 2q Adhesive luting: Removal of resin composite excess in the interproximal zone with Superfloss.
Fig 2r Adhesive luting: Polymerization of the luting composite with a high-power LED curing device at least 60 seconds per surface. Intermittent cooling by compressed air and water spray may be necessary during light curing.





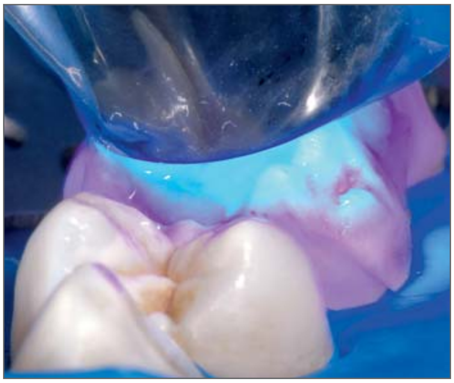


Fig 2s Finishing/polishing: After curing, the restoration margins are polished with progressive fine diamonds and plastic strips.
Fig 2t After polishing, a final application of highly concentrated fluoride gel is recommended.
Fig 2u Luting composite is finally polymerized through the fluoride gel for 5 seconds per surface to avoid an oxygen-inhibition layer, if still present.

Fig 2v Occlusal view of the restored molar 1 week after luting.

and patient's eyes must be protected with protective glasses, and a powerful chairside aspiration must be used. Airborne-particle abrasion cleans the cavity in an optimal way and, at the same time, conditions the resin composite surface for bonding.

Subsequently, enamel margins are etched using 35% to 37% H_3PO_4 etching gel for 30 seconds (Figs 2j and 3e). The etching gel is first aspirated at high speed, then rinsed with a water jet, and finally rinsed with copious water spray for at least 30 seconds. The cavity is then perfectly dried with oil-free compressed air. Before application of the bonding agent, the conditioned resin composite surface is "primed" with a prehydrolyzed 1-bottle silane coupling agent (eg, Monobond S, Ivoclar Vivadent) for 60 seconds and subsequently well dried with heated compressed air to remove the solvents (Fig 2k). The accidental application of silane on conditioned enamel does not have any negative effect on enamel adhesion.[6] Finally, a light-curing bonding resin is applied onto the entire cavity surface and spread in a very thin layer with a gentle air jet, without being precured (Fig 2l).

In the next step, an adequate amount of restorative light-curing resin composite is inserted into the cavity (Figs 2m and 3f). To decrease its viscosity, it may be heated up to about 50°C (with, eg, Calset, AdDent). It is important that the material be spread all over the cavity floor and walls, because—even if heated—it will not flow under pressure of the overlying restoration as easily as a fluid dual-curing luting composite would. Immediately thereafter, the prepared restoration is inserted into the cavity and fixed in place manually by applying pressure on the occlusal surface with a large plugger (Figs 2n and 3g). A final additional push of the restoration with a plastic-coated ultrasonic tip helps to seat the workpiece into the definitive position (Fig 2o).

Fig 3a Initial view of a maxillary right second premolar under rubber dam isolation before the adhesive procedure. Note the finished enamel margins and the thin resin composite layer on dentin and in the boxes.
Fig 3b Initial view of the laboratory-made resin composite restoration.
Fig 3c Preparation of the workpiece: The inner surface of the restoration is mechanically conditioned by abrasion with 50 µm Al_3O_2 particles before silane and bonding resin application.

Fig 3d Conditioning of the cavity: Air abrasion of the resin composite base of the cavity.
Fig 3e Conditioning of the cavity: Etching the enamel margins with 37% H_3PO_4 gel.
Fig 3f Adhesive luting: Preheated restorative resin composite is spread into the entire cavity before insertion of the restoration.

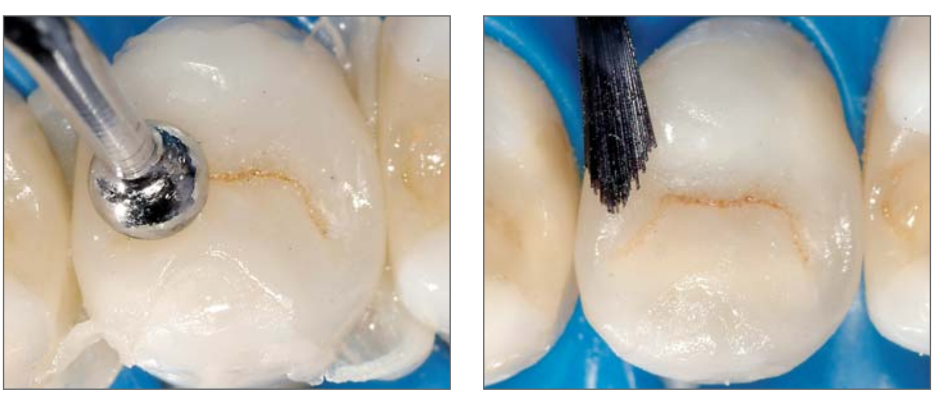


Fig 3g Adhesive luting: Seating the workpiece.
Fig 3h Adhesive luting: Removal of luting composite excesses.

Figs 3i and 3j Once the luting composite is light cured, cavity margins are finished and polished.
Fig 3k Final short polymerization of the luting composite through the fluoride gel.

Fig 3l Palatal view of the luted restoration before rubber dam removal.
Fig 3m Occlusal view of the restored premolar 3 days after the luting appointment.

Excess luting composite is removed with a fine spatula or a probe and by using Superfloss (eg, Oral-B Superfloss, Gillette) in the interdental area (Figs 2p, 2q, and 3h). Since the luting composite is photoactivated, the clinical time needed for this phase is infinite and completely under the operator's control. However, care has to be taken to avoid focusing the operator's light directly on the workpiece.

A first light polymerization, which serves to fix the surface of the luting composite, is performed for 5 seconds per surface using a high-power light-emitting diode (LED) light-curing unit. Then full polymerization is achieved by light curing for at least 60 seconds per irradiated surface (Fig 2r). To avoid heat accumulation during this long-term light curing, the tooth is cooled intermittently with compressed air and water spray to avoid tooth desiccation (Onisor I, Asmussen E, Krejci I, unpublished data). Any excess composite is then removed with fine diamonds and repolished with flexible disks or silicone points with slight pressure (Figs 2s, 3i, and 3j). A layer of highly concentrated fluoride gel (eg, Elmex Gelée, Elmex) is finally applied over the entire surface of the restored tooth, and the luting composite is cured for 5 seconds per surface through this gel to eliminate the oxygen-inhibition layer on the surface of the luting composite, if still present (Figs 2t, 2u, and 3k).

Finally, after removal of the fluoride gel, rubber dam is removed and occlusion is checked. Since cavity margins have been placed out of occlusal contacts,[1] any eventual occlusal correction are done on the restoration without touching the sound tooth surface.

Fig 4a Silica-based ceramic restoration.
Fig 4b Silica-based ceramic adhesive preparation: Conditioning of the inner surface of the restoration with 5% hydrofluoric acid for 60 seconds.
Fig 4c Hydrofluoric acid is first aspired through high-speed aspiration.

Fig 4d Hydrofluoric acid is rinsed by a water jet.
Fig 4e The restoration is then abundantly rinsed with water spray for at least 30 seconds.
Fig 4f The restoration is gently dried with oil-free compressed air.

DISCUSSION

Luting of indirect restorations is actually based on adhesive techniques that are widely advocated for many fields of restorative dentistry.[7] The purpose of adhesive cementation is to create an intimate contact between restoration and tooth cavity through a thin layer of resin cement: The adhesive interface is a kind of multilayer sandwich in which similar or dissimilar substrates are coupled. At mouth temperature and in the short period of time available for adhesive luting, physical adhesion is considered to be the main mechanism at work.[7] Therefore, conditioning, priming, and bonding are fundamental steps in adhesive preparation of the involved hard surfaces.

Adhesive treatment of the workpiece

While silane and hydrophobic bisphenol glycidyl methacrylate (bis-GMA) resin are generally considered the best means to prime and bond all conditioned surfaces, conditioning varies according to the composition of the restorative material (see Table 1).

For silica-based ceramic restorations, conditioning is achieved by using 5% hydrofluoric acid (eg, Vita Ceramics Etch, Vita Zahnfabrik) for 1 minute, which promotes optimal morphologic changes of the surface for the physical penetration of the silane coupling agent. For this type of ceramic, silane acts principally as promoter of wettability of the roughened surface for the successive application of the bonding agent. Higher concentrations of hydrofluoric acid or prolonged time of appli-

Fig 4g Prehydrolyzed silane coupling agent is applied for 60 seconds.
Fig 4h Silane is gently dried with warmed compressed air.
Fig 4i A thin layer of bonding resin is subsequently applied over the silanized surface.

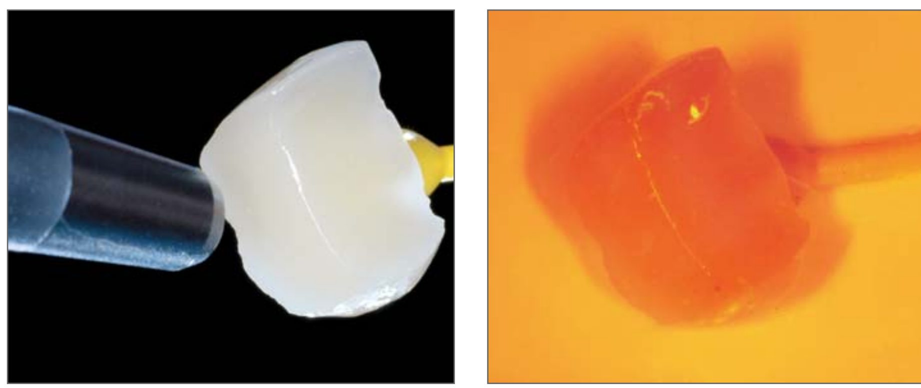


Fig 4j Shiny aspect of the inner surface of the restoration after bonding resin application.
Fig 4k After surface adhesive treatment and before insertion, the restoration is put under protection from light.

cation are not recommended because of the danger of precipitate formation, which would need further treatments to be removed.[8–10] Likewise, airborne-particle abrasion of the surface of conventional vitreous ceramic induces only macromorphologic changes and may provoke “chipping.”[11,12]

All types of indirect resin composite restorations are conditioned through abrasion with 30 to 50 µm Al_2O_3 particles, followed by silane application, which primes the conditioned surface for the subsequent application of the bonding agent. Resin composite surface treatment through hydrofluoric or orthophosphoric acid is selectively directed against the inorganic particles of the composite, weakening the organic matrix, and therefore, they are not recommended.[13]

For all types of indirect restorations, fabricated with ceramic or resin composite, the authors advise against pretreating of the restorations for adhesion by the dental laboratory because there is the danger of irreversible contamination of treated surfaces during storage, transport, and try-in. As an example, if a ceramic inlay is already etched with hydrofluoric acid in the laboratory, a recommendation is given to clean the etched surface with phosphoric acid after try-in. However, the fragile etching pattern may partly be mechanically destroyed during try-in, and in such a case, cleaning with phosphoric acid will not help. If the inlay is hydrofluoric-acid-etched and silanated, the silanated surface will be contaminated by air moisture during storage. Finally, if the inlay is hydrofluoric-acid-etched, silanated, and bonded in the dental laboratory, the bonding layer will most probably not have enough free radicals to chemically attach to the luting composite.

Adhesive treatment of the cavity

The purpose of the first appointment is to leave the cavity with only 2 substrates—ground enamel and a thin layer of resin composite that covers the entire dentin surface, occlusally relocates subgingival cervical margins, and eliminates cavity undercuts. Before adhesive luting, the resin composite layer is conditioned through airborne-particle abrasion and primed with silane, while enamel is conventionally etched with orthophosphoric acid. Hydrophobic bonding resin is then applied on both substrates but not precured. This procedure simplifies adhesive treatment and reduces the numbers of steps and materials used, allowing a less technique-sensitive procedure.

Other steps during the second appointment are also simplified by the resin composite coating technique: First, sealed dentin allows for the use of a noncemented soft resin (eg, Fermit, Ivoclar Vivadent) as a provisional restoration that is easily removed without leaving remnants of temporary luting cements.[14,15] The definitive restoration is quickly tried in the cavity, and no particular mechanical or chemical treatments other than airborne-particle abrasion are needed to clean the cavity. The supragingival relocation of subgingival margins through resin composite application facilitates rubber dam application, which is mandatory during adhesive procedures. Moreover, the thin composite layer protects the hybridized dentin and thus enables safe airborne-particle abrasion and the creation of perfectly dry conditions for adhesive luting. As an additional benefit, local anesthesia may not be necessary because, during the first appointment, dentin tubuli are immediately sealed (hybridization) and covered by resin composite, which acts as a physical and chemical barrier.

Luting composite

When luting a resin composite or ceramic indirect restoration, the ideal luting agent should guarantee a durable bond between the involved structures, a good marginal adaptation, and additional attributes like optimal biomechanical properties, low solubility in the oral environment, radiopacity, increased working and setting time for easy manipulation, adequate viscosity for complete seating, and optimal esthetic properties.[16] At present, conventional cements (zinc phosphate, zinc eugenol, polycarboxylate, or glass ionomer) are no longer indicated, and resin composites are materials of choice in adhesive luting. Unfortunately, numerous products are commercially available with different polymerization initiation modes (auto, photo, or dual activated), adhesive properties (resin cements associated with an adhesive system, reactive-monomer-containing or self-adhesive cements), and different viscosities.

For the presented luting technique, the authors recommend the use of light-cured restorative hybrid composites together with a compatible light-cured adhesive system. There are several reasons for this recommendation: First, restorative resin composites exhibit the best biomechanical properties and a lower polymerization shrinkage stress. Furthermore, their higher viscosity ensures an easier handling during removal of composite excesses. However, higher viscosity may impede complete seating of the restoration. Even if preheating makes the restorative composite more fluid, it is very important to spread it all over the cavity before the insertion of the workpiece and to use the ultrasonic insertion technique. Moreover, light-cured restorative composites have better storage stability than auto- or dual-cured resin materials, they guarantee an unlimited working time, they provide a large choice of shades, and, finally, they avoid an additional material in the dental office just for luting. In addition, dual-cured luting composites show lower hardness without light curing, meaning that even if chemical curing may take place, the best choice of polymerizing dual-cured materials is to irradiate them by light.[17,18] The proposed technique implies a resin composite base within the cavity, reducing the thickness of the subsequently applied indirect restorations. Together with the use of high-power second-generation LED light-curing units at a sufficiently long curing time, the use of purely light-cured resin composites as luting agents is possible.[19,20]

The recently developed self-adhesive cements show a limited bonding effectiveness to enamel if the latter is not acid etched before luting.[17,21] Because a significant number of ceramic and resin composite laboratory-made restorations are located in enamel, the use of these cements cannot be recommended.

Adhesive luting of indirect posterior restorations is a complex procedure that requires a thorough understanding of the adhesive principles and perfect planning of the clinical procedures. Following the adhesive philosophy and due to improvements in materials and techniques, the simplified approach described in this and the previous publication[1] may provide predictable luting results in indirect restoration of the posterior dentition.

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