Kornberg School of Dentistry
TEMPLE UNIVERSITY®

EVIDENCE-BASED GUIDELINES
For Planning and Placing
Direct Class II Resin-Based Restorations

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Clinical decision-making is a complex process that integrates a critical appraisal of the best available scientific evidence with the experience of the dentist and the patient's desires and expectations. The ultimate goal is to provide the best possible treatment outcomes, including optimal comfort, function, esthetics and longevity of dental restorations.

The objective of this document is to help the student clinician make sound decisions regarding direct posterior resin-based composite (RBC) restorations. Published papers are cited to provide a scientific basis for these practice guidelines and may be used as a resource by the student and attending instructor to develop a more in-depth understanding of the various procedures and techniques. Relevant long-term, randomized, controlled clinical trials and systematic reviews of clinical studies are cited as the preferred source whenever possible. It should be noted that there is a general lack of studies correlating laboratory (*in vitro*) tests with long term clinical (*in vivo*) performance[14].

The Cochrane Collaboration has planned an upcoming critical review to examine the effectiveness of direct composite resin restorations compared to amalgam fillings for permanent posterior teeth (restorations lasting 3 years or more). The protocol has been published for the review at: Lu H et al. Direct composite resin fillings versus amalgam fillings for permanent or adult posterior teeth. (Protocol) *Cochrane Database of Systematic Review 2006,* Issue 1. Art. No.: CD005620. DOI: 10.1002/14651858.CD005620. This can be reference online at TU Library.

I. CASE SELECTION: Criteria for choosing the most appropriate direct restorative material

Resin-based composites (RBCs) and dental amalgam both have inherent benefits and risks, which are particularly evident when utilized in Class II applications[1]. If cost/benefit factors are the primary concern, amalgam, due to excellent longevity data from clinical studies lasting up to 20 years, is still the most convenient, predictable restorative material for multi-surface posterior restorations[2,3,4].

RBCs may be recommended as a good alternative to dental amalgam[29] where:

1. Natural appearance is paramount.
2. The occlusal outline form is small to moderate[90].

As a general rule, the faciolingual width of the occlusal cavity preparation should not exceed one-third the inter-cuspal dimension[66]. However, some studies report acceptable performance with greater widths[16]. Large RBC restorations that restore several occlusal contacts exhibit a greater rate of wear (two-body or wear by attrition) than dental amalgam[9]. Heavily filled (>60% filler by volume) hybrid composites are considered best suited for posterior use.

3. The gingival cavosurface margins are located in enamel (on the anatomic crown).

The bond that can be achieved *in situ* to enamel is more reliable and durable than the bond to dentin[12,13]. Polymerization shrinkage is responsible for interfacial gap formation, which in high risk patients leads to secondary caries, a principal reason for restoration failure [6,82], and possibly post-operative sensitivity[8]. Increased adherence of cariogenic bacteria to RBC surfaces may be a contributing factor[7].

4. The surgical site can be isolated effectively from contamination[14].

Rubber dam is especially important when expert assistance is unavailable (virtually all cases in the School of Dentistry) and is the most reliable method of operating field isolation.

Some patients may express concerns regarding any possible toxic effects of dental amalgam. This would best be addressed by referencing the ADA position statement. which cites considerable evidence of the safety of amalgam.

Several other applications of RBCs in posterior teeth may be considered.

Due to their reliable bond to enamel, RBCs are especially well suited for occlusal sealants and preventive resin restorations, which entail minimally invasive preparation of fissures that conserve tooth structure and strength. Limited clinical data exist supporting the effectiveness of RBC in cracked teeth[10,11] or for primary prevention of cusp fractures by virtue of the enamel/dentin bond in teeth with large preparations[5].

Severely damaged posterior teeth with a questionable prognosis may be candidates for RBCs as interim restorations, where successful long-term performance is not a requirement. These patients may require frequent post-operative recalls. Large posterior RBC restorations may be used effectively as core build-ups for teeth that will be restored with crowns.[100,101] Amalgam due to its high fracture toughness also would be suitable as a crown foundation.[102] The selection of the optimum core material depends on clinical judgment and the specific clinical situation.

Conversely, dental amalgam is recommended in Class II applications where:

1. The proposed restoration will be wide, replace a functional cusp or extend onto the anatomic root.
2. The occlusal contacts are located predominately on surfaces that will be occupied by the restoration, with little or no contact on tooth structure. The occlusal function of the restored tooth can be predicted by locating the occlusal stops with articulating paper prior to beginning the restorative procedure.
3. Occlusal stresses are heavy, especially in patients with uncontrolled parafunctional habits (*e.g.,* bruxism)[15,16] or a partial dentition resulting in greater occlusal demands on fewer teeth.
4. The patient is at high risk for dental caries or exhibits poor oral hygiene[17].
5. A rest seat for a RPD cast metal framework will be prepared into the restoration. Although there is no convincing scientific evidence that amalgam is better than composite in supporting a RPD, it may still be the material of choice due to excellent durability/longevity.[2,3,4]
Wear and overall life expectancy of the restoration are important treatment planning factors for RPD abutment teeth.
6. Low cost is a priority.

SOME POINTS TO REMEMBER:
Since both materials have properties that lend them to some – but not all – Class II applications, direct resin-based composite should be considered an alternative to dental amalgam, not an ideal replacement. Good judgment in case selection affects the performance and longevity of Class II restorations, and a well-informed patient can and should be a partner in the selection process.

II. TOOTH PREPARATION FOR DIRECT CLASS II RBC RESTORATIONS

The preliminary design for a tooth preparation may be envisioned at the time of the examination based on the apparent location and size of the caries lesion(s). The occlusal and proximal surfaces should be evaluated and managed as distinct entities whenever possible, beginning with an initial conservative design and followed by a more invasive operative intervention as lesions in dentin are revealed[29].

It is not always necessary to completely break proximal contact with the adjacent tooth when preparing the proximal box. If all the carious and weak tooth structure can be removed conservatively, preserving even a small portion of the natural contact area with the adjacent tooth will help assure a satisfactory proximal contact once the restoration is complete. However, breaking contact completely may be warranted in many cases to access an extensive caries lesion in dentin, to remove demineralized enamel, or to facilitate the placement of a matrix or the finishing of the restorative material. Accordingly, breaking contact is a matter of clinical judgment, not an absolute requirement for all Class II preparations.

These additional points should be considered *prior to beginning the preparation* and are applicable to all cavity designs:

1. Marking and noting the occlusal contacts in MIP and eccentric movements with articulating paper/film may facilitate the occlusal adjustment of the final restoration.
2. Placing a wooden wedge before beginning the preparation ("pre-wedging") and frequently reapplying seating pressure has been shown to separate teeth effectively and facilitate the restoration of tight proximal contact[18,19].
3. Choosing carbide or diamond burs for high speed removal of tooth structure is a matter of personal preference. They are equally effective[21,30].

The following series of preparation designs represents a progressively invasive operative approach:

1. **Box-only (slot) Class II Preparation**

A slot preparation resembles the proximal portion of a conventional preparation without any involvement of the central groove[98]. It is indicated for teeth with a small proximal caries lesion and sound occlusal grooves. The axial depth and proximal extension are determined by the size of the lesion and internal line angles are rounded. Retentive grooves/locks in the facial and lingual walls 0.5 mm into dentin, extending from the gingival wall out to the occlusal surface, may provide a positive influence on fracture load and retention comparable to an occlusal dovetail[25,26,27].

2. Conservative Class II Preparation (Preventive Class II Restoration)

This design is indicated for teeth with small proximal lesions and deep occlusal fissures with some limited caries involvement. The proximal caries lesion is eliminated with a proximal slot (as above) and the occlusal surface is prepared separately as for a Class I PRR, beginning with fissurotomy and following lesions into dentin only as necessary. The preparation preserves as much occlusal tooth structure as is practical, and undercuts are not required. (Note: If the occlusal fissures are deep, but there is no evidence of caries activity, the fissures may be sealed without any invasive instrumentation.)

3. Conventional Class II Preparation (GV Black guidelines)

The conventional design resembles a Class II preparation for amalgam with some modification, and is indicated for teeth with proximal lesions and more extensive caries involvement of the occlusal fissures. The facial and lingual walls may diverge slightly or remain parallel in a occlusal direction. The isthmus dimension is as narrow as possible, given the location and size of the occlusal lesions. Secondary retentive features (retentive grooves) are not usually required.

Guidelines for the use of cavosurface bevels:

1. Occlusal bevels are not indicated and offer no clinical benefit[40,41].
2. Beveled vertical proximal walls may help to reduce microleakage[31]. If the facial and lingual margins of the proximal box are flared slightly (form an obtuse angle with a matrix band), then no additional bevels are necessary, since enamel rods are sufficiently exposed for acceptable bonding.
3. In small box-only preparations with sharp facial and lingual external margins, conservative proximal bevels placed with hand instruments or fine grit diamonds may improve the marginal seal and facilitate finishing/polishing[22].
4. Gingival bevels generally are not indicated. However, one study supports bevels in preparations with sufficient residual enamel height (> 1 mm from CEJ) for better marginal adaptation[23].
5. If carious dentin excavation results in an internally slanted edge of unsupported enamel at the gingival margin, a hand instrument (e.g., enamel hatchet or gingival margin trimmer) is recommended to remove thin/friable enamel only. It is not necessary to place an external bevel or create a butt-joint cavosurface margin[24].

SOME POINTS TO REMEMBER:
Conservation of tooth structure is an important goal of cavity preparation. In general, outline extension is limited to accessing and eliminating carious and fragile tooth structure while preserving healthy tissue, including any unsupported enamel that appears sturdy. However, the outline form must be extensive enough to facilitate the removal of the caries lesion in dentin, which remains the standard of care.

III. BASES/LINERS FOR DIRECT RBCs

A calcium hydroxide liner (*e.g.,* DYCAL) is indicated exclusively in preparations where the remaining dentin thickness (RDT) is less than 0.5 mm, that is, a *near* pulp exposure evident as a "blushing" (indirect pulp cap), or to treat an actual pinpoint exposure (direct pulp cap). It is the material of choice for pulp capping because it is associated with dentin bridging[32,33]. A thin layer[97] of resin-modified glass ionomer (RMGI), e.g., Vitrebond, is then applied over the calcium hydroxide due to its superior resistance to acid dissolution.

In moderately deep preparations (RDT 0.5-2.0 mm) or if the gingival margin approximates the CEJ, a RMGI liner is indicated to help decrease microleakage[34] as well as reduce polymerization shrinkage (and possibly post-op sensitivity) by reducing the volume of composite required[35,36]. It should be noted that post-op sensitivity appears to be primarily associated with dentin adhesives' ability (or inability) to seal open dentinal tubules[86].

The ability of glass ionomer to bond to tooth structure and RBCs, and release fluoride, is well documented[83,84]. Also, glass ionomer may help reduce sensitivity in the immediate post-op period as compared to adhesive alone[85].

RMGI placed as the initial increment on the gingival wall of the proximal box, extending from the axial wall to the cavosurface margin (referred to as the "bonded base" or "open sandwich" technique), has been considered a possible strategy where a Class II RBC restoration extends apical to CEJ. Some studies have shown gap-free marginal adaptation and decreased microleakage[37,38], but there exists very little long-term (>5yrs) *in vivo* data regarding durability and clinical performance. This variation is not routinely promoted by Sturdevant[98], nor widely accepted by practicing clinicians[37,38,39,97].

The use of flowable resin liners (low-viscosity, lightly filled resin) is gaining popularity among clinicians. It is thought that this material, when applied to the pulpal or axial wall, may more closely adapt to all areas of the preparation and prevent internal voids[36]. Intuitively, there may seem to be a potential benefit, but consideration must be given to any resultant undesirable effects due to the inferior physical properties of these materials. Since most studies, including clinical trials, neither support the use of flowable resins to reduce microleakage and post-op sensitivity nor demonstrate improved overall clinical performance, they are not recommended[42,43,44,45].

SOME POINTS TO REMEMBER:
Conservative, shallow preparations for RBC require an adhesive resin only (no liner/base). When calcium hydroxide is indicated, it should be used sparingly and covered with a RMGI. RMGI should be confined to the dentin and not extended to the external margins of the proximal box prior to inserting the first increment of RBC. RMGI is a biocompatible material

with several other well-documented advantages and is the material of choice where a liner is indicated.

IV. MATRIX APPLICATION

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Normal proximal morphology and tight proximal contact are essential to the long-term success of Class II RBC restorations. Poor proximal contact promotes food impaction, which in turn may increase the risk of periodontal disease and dental caries. Achieving tight proximal contact is largely a function of mechanical tooth separation. The choice and proper use of a matrix system is important in this regard. Placing the matrix before initiating bonding procedures may help isolate the proximal box and prevent etching adjacent teeth.

There are 2 basic matrix systems to consider:

1. Conventional circumferential matrix held in place with a mechanical retainer (*e.g.,* ultrathin Tofflemire or HO Band dead-soft metal band, pre-contoured clear plastic band). Circumferential metal bands must be contoured after placement by burnishing. A wedge (usually made of wood) must be used to achieve tooth separation.
2. Sectional pre-contoured metal matrix (*e.g.,* Palodent, Composi-Tight). These are used with spring-like separation rings, usually in conjunction with a wooden wedge.

Clear plastic matrices allow for curing from proximal and gingival directions, but due to added thickness and flexibility they may be difficult to insert and require a greater amount of tooth separation to achieve tight proximal contact. Dead-soft metal matrices are generally preferred due to the thin gauge (.001 inches) and ease of placement. It is important to cure the proximal resin facially and lingually after removing the metal band.

In many situations sectional/ring matrix systems provide excellent tooth separation, good adaptation and a more ideal anatomic proximal contour in the final restoration compared to circumferential bands. However, some types of separation rings with wider tines may be difficult to place relative to the wedge in preparations with narrow facial-lingual extension. Likewise, these rings may deform the matrix band in wide preparations resulting in poor proximal embrasure form. Familiarity and some experience with these systems are needed to achieve good results. *(click here for audio instruction link)*

SOME POINTS TO REMEMBER:
The final preparation and pre-existing arch alignment will dictate which matrix system offers the best mechanical advantage to achieve optimum contour and proximal contact. Studies that compared various matrix systems suggest the most predictable proximal contacts are obtained with the sectional/ring systems, if properly selected and placed[46,47].

V. ADHESIVE/BONDING PROCEDURES

Due to significant technical and procedural differences among the various bonding systems, it is critically important to adhere to the manufacturer's instructions. Prime&Bond NT (a 5th generation adhesive) is reported to have bond strengths comparable to the "gold standard" 4th generation systems (2-bottle, 3-step) if exercising good technique[12].

Total-Etch (Etch and Rinse) Technique – Step-by-Step Guidelines for Prime&Bond NT:

1. Apply phosphoric acid gel directly from the syringe to cut enamel first, wait 20-30 sec, then apply etchant to all exposed dentin for 15 sec. Controlling etching times helps prevent overly demineralizing dentin and incomplete adhesive resin infiltration[48,49].
2. Rinse off the etchant gel with a stream of water for 10 sec, preserving a clean, contamination-free field. Remove pooled water by blotting the dentin surface with a damp cotton pellet (avoid rubbing), or by very gentle air-drying. Moist dentin, indicated by a shiny hydrated surface, is critical for effective dentin bonds when using adhesives with water-free primers and acetone solvents, such as Prime&Bond NT[50].
3. Apply adhesive in multiple coats with a mild dabbing motion, allowing the surface to remain fully wet for 20 sec, followed by gentle uncontaminated air-drying for at least 5 sec to evaporate primer solvents[51,52].
4. Light cure the adhesive for 20 sec prior to composite placement.
5. Once preparation surfaces have been properly conditioned, it is critical to maintain field isolation. If there is a suspicion of salivary contamination, repeat the above steps.

SOME POINTS TO REMEMBER:
Adhesive bonding is a critically important aspect of this operative procedure and has a significant effect on performance and longevity of the final posterior RBC restoration.
Avoid these common errors…

- **Over-etching dentin and/or under-etching enamel**
- **Over-drying dentin after rinsing off the etchant**
- **Excessive moisture after rinsing off etchant[50]**
- **Insufficient application of bonding agent[51,52]**
- **Overly aggressive solvent evaporation/air thinning**
- **Inadequate evaporation of solvent, *i.e.* residual moisture or solvent**

VI. COMPOSITE RESIN PLACEMENT AND POLYMERIZATION

Since visible light-cured RBC materials have a limited depth of cure, they must be placed in increments, usually not exceeding 2 mm. In addition to promoting thorough polymerization, incremental placement has been recommended by some investigators and textbook authors to reduce the potential for microscopic gap formation between the set restorative material and the prepared cavity walls, and possibly reduce cusp deflection during polymerization[56,57,58].

Several different incremental layering techniques have been studied using clinical and laboratory methods. In theory, it may be possible to limit gap formation or cusp deflection by reducing the number of bonding surfaces contacted by any given increment[54,55]. An oblique layering technique that avoids building a continuous horizontal bar of material spanning from the facial to the lingual surface has been proposed and may have some benefits[54,55].

The scientific evidence supporting any of these principles or techniques is not especially strong, as some studies have yielded conflicting results[94,95,96] and there is a general lack of data from clinical studies establishing a cause and effect relationship between polymerization stress and failure of RBC restorations[62]. However, since secondary caries is one of the main reasons for RBC failure, it is important to make every effort to minimize gap formation at the tooth-resin interface.

The following technique is recommended to manage the polymerization shrinkage that is inevitable with all direct RBC materials:

1. Apply the initial increment of RBC, such as TPH3 Restorative, to the gingival wall of the proximal box in a layer less than 1 mm thick using a shade with the greatest depth of cure (typically lighter than

the matching enamel shade)[53]. It may be helpful, due to the often sticky nature of the resin, to lightly moisten the tip of the plastic instrument with adhesive or wipe it with alcohol gauze to prevent pulling the material away from the bonding surfaces.

2. Cure this and all subsequent increments for a minimum of 20 sec, holding the light tip 3-6mm from the restorative material[59,60]. If using a halogen light source, always confirm that the intensity of the light meets industry standards[53] (Minimum power output-350 mW/cm^2). Composite resin build-up on the curing light tip may reduce the light intensity[99]. A directed light curing technique using clear matrix bands has been proposed, but the evidence that polymerization shrinkage is significantly affected by the orientation of the incoming light is inconclusive[61].

3. Insert subsequent increments in an oblique "ramping" fashion, alternating between facial and lingual walls, or horizontally, but in any case making sure the increments are no thicker than 2 mm. This technique contributes to improved bond strengths and may reduce polymerization stresses[54,55].

4. Conform the last increments to the surrounding enamel surfaces, mimicking normal occlusal morphology and minimizing resin excess beyond the cavosurface margins. This method reduces finishing time and the potential for damaging surrounding enamel.

5. After wedge and matrix removal, cure the facial and lingual aspects of the proximal boxes to ensure complete polymerization.

SOME POINTS TO REMEMER:
RBC restorations that are greater than 2 mm deep require an incremental placement technique due to the limited depth of cure of the restorative material. The increments should never exceed 2 mm in thickness and the curing light source should be held as close as possible.

Based on the best available evidence, thin layers placed in a meticulous manner may be expected to produce the least contraction stress, insure completeness of cure, proper adaptation to cavity walls, and possibly reduce cusp deflection[56,57,58].

VII. FINISHING AND POLISHING

There is a wide array of finishing and polishing instruments and materials marketed to dentists for use with RBC restorations, some of which have been subjected to independent testing. The following sequential technique is recommended based on the best available evidence.

1. Gross finishing

Remove substantial excess with 8-12 fluted carbide finishing burs or fine finishing diamonds (red stripe) in the high-speed handpiece using air-water spray, a light touch and intermittent contact. An air/water spray used during finishing helps to evacuate cutting debris and is required when using finishing diamonds, due to the greater frictional heat created. Carbide finishing burs may be used without water when running in the low end of the high-speed range[69,71] and were shown in one study to result in greater wear resistance of the finished surface compared to wet fine diamonds[87].

Dry the surface and evaluate progress frequently so as to avoid damaging the surrounding enamel. Iatrogenic loss of tooth structure is a risk of rotary instrumentation, especially when using the high-speed handpiece, and overaggressive finishing may also create micro-cracks in the resin[63].

The following Brasseler Esthetic Trimming carbide burs are useful for finishing RBC restorations:
    #7406 for primary occlusal anatomy and initial carving
    #ETS7 or ETS8.5 (8-fluted safe end) for marginal ridge, proximal embrasure finishing

#7801 for secondary contouring and refining of occlusal grooves

2. Fine Finishing and Polishing

Switch to the low-speed handpiece to create the final occlusal form, shape the proximal embrasures and remove any remaining flash at the cavosurface margins. It is desirable to use fine carbide finishing burs at this stage instead of finishing diamonds (yellow stripe). Finishing diamonds may cut more efficiently, but carbide finishing burs leave a smoother surface with many micro-hybrid RBCs[69,87,88].

Remove the rubber dam and evaluate occlusal contacts in MIP (maximum inter-cuspal position) with articulating film and adjust as necessary. Eliminate any interferences that are identified during excursions of the mandible.

Refine the surfaces with fine flexible polishing discs (e.g., Sof-lex Discs, 3M) and abrasive-impregnated rubber polishing devices (e.g., Enhance, Caulk/Dentsply). Small bullet-shaped points are useful for occlusal fossas and cusp ridges. Discs and cups may be used to refine occlusal embrasures and those proximal portions of the restoration that extend into the facial and lingual embrasures.

Smooth the gingival margin with fine extra-narrow finishing strips, taking care not to abrade the proximal contact area. Finishing strips have a central "gap" that is free of abrasive and permits passing the strip into the gingival embrasure without altering the contact relationship.

Polish the surface with an aluminum oxide paste, preferably applied with a felt or foam device[70]. Polishing pastes are particularly effective with micro-hybrid RBCs (*e.g.,* TPH) and should be applied first dry, then with increasing amounts of water on the surface of the composite, producing a very smooth light reflective surface[70].

3. Post-Curing

Once the final morphology and surface polish have been achieved, expose the restoration to the curing light from all directions. Under certain testing conditions post-curing has been shown to improve mechanical properties, including tensile strength and microhardness[72].

4. Surface Sealing

Re-etch the surface of the restoration and 1-2 mm of the surrounding enamel and apply a low viscosity surface penetrating sealant (*e.g.,* Seal and Protect [off-label use] or Fortify). A surface sealant may be beneficial in reducing wear rates, marginal staining, and enhancing marginal integrity in the short term [74,75], as well as filling micro-defects in the resin[76]. A recent *in vitro* study reported that sealants effectively reduced microleakage[77]. The longevity of surface sealants is not known.

SOME POINTS TO REMEMBER:

The best possible surface finish for RBC restorations is achieved by following a sequential procedure using progressively less abrasive finishing/polishing instruments and materials. A satisfactory polish cannot be achieved with finishing diamonds alone. After polishing, application of a surface sealant may be beneficial for posterior restorations.

A very smooth RBC surface is important because it is esthetic and may improve wear resistance and minimize biofilm formation, potentially increasing the longevity of restorations.[64,65]

In conclusion, certain aspects of the direct posterior RBC restorative procedure are controversial because the body of scientific evidence is incomplete and the experience of clinicians is often quite variable. However, there is general agreement that RBC restorations are highly technique sensitive, requiring careful attention to field isolation, adhesive application, selection and placement of matrices, insertion and curing of the resin, and finally finishing of the restoration. Consideration must also be given to appropriate case selection during treatment planning.

It is with this understanding that clinicians appreciate the potential benefits and the limitations of posterior Class II RBC restorations. Meticulous technique with the utmost attention to detail will offer the best chance for long-term clinical success.

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