Preparations In Composite Resin Part I: Principles And Instrumentation For Class V, Cusp Tips, And Incisal Attrition

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PREPARATION DESIGN FOR COMPOSITES

The definitive textbook of composite restoration has yet to be written. Preparation designs are a common starting point in clinical technique before other complex variables such as resin, placement, shrinkage, and cure are encountered. This article explores principles, designs and instrumentation revised for composite resin Class V preparations, and new preparations to treat Incisal and Cusp Tip Attrition.

This material is drawn from a composite resin study club operating on Vancouver Island in British Columbia led by the author since 2004. A later article will cover Class II, MODB, and complex multisurface posterior preparations.

ENAMEL AND DENTIN AXIOMS

All our data on enamel adhesion is laboratory-based on fresh cut facial bovine enamel. To achieve the megapascals promised by these tests, we need to duplicate these conditions clinically. Five enamel axioms, if applied, create ideal enamel adhesion conditions. Similarly, five dentin axioms drive preparation internal form. These supplement classic GV Black cavity design principles.

THE IMPORTANCE OF ETCH:

The importance of etch as a variable should be discussed before considering these axioms. Etched enamel, properly accomplished, increases surface area 1000 to 2000 percent.[1] Etched coronal dentin falls far behind, at 250 to 400%. Within the root canal, intracanal dentin area increase after etch varies from 150% to 250%, depending on depth of the canal and age of the root.[2] However, these theoretical increases depend upon adequate etching. Etchants used in Total Etch Technique (etch-and-rinse protocols) vary widely in efficacy.[3] Table 1 illustrates that a ten-fold variation in efficacy exists in commercial etchants. Note that 37% liquid phosphoric acid is still superior to most gels.

Self-etching adhesives show equally wide variation in pH and enamel etching efficacy.[4] Thus, even ideal preparations will under-perform if acid etching, either separately or embedded in the adhesive, falls below criteria. Being an invisible parameter, the importance of etch to longevity is often overlooked, but resin technique is unfortunately inherently complex and exacting.

1. ENAMEL AXIOM #1: ALWAYS FRESH CUT ENAMEL

The external surface of natural teeth is a remineralized, highly fluoridated layer which averages 10 microns in thickness.[1] This layer resists etching, particularly since fluoridated toothpastes have achieved widespread use. Therefore, as a fundamental principle in all prep design, it must be removed.

What is not widely understood is that reparative enamel crystals of this layer also have no rod structure.[5] Remineralized enamel is disorganized, being generated from salivary constituents, and is not cohesive with underlying enamel rods. If we bond to remineralized enamel, we face a structural disconnect from underlying enamel rod-ends.[5]

Optimum rod-end enamel etching increases surface area ten to 20 fold and penetrates up to 20 microns.[1] Stable, cohesive adhesion depends upon gripping these rod-ends.

Operator preference and clinical opportunity determine whether rotary burs, ultrasonic instrumentation, or light air abrasion will be used: all are effective in removing this 10 micron layer of remineralized enamel.

"Prep-less restorations", i.e., enamel untouched by the operator, will unfortunately be categorically inferior in retention and seal for this reason. Preserving ten microns of tooth structure in the name of conservatism is misplaced and erroneous design.

5 Resin Axioms for Enamel
1. Always fresh-cut
2. Always rod-end bonding
3. Always a bevel, except on occlusal surfaces
4. Margin extension for Wear
5. Margin extension for Contraction Resistance

5 Resin Axioms for Dentin
1. Always fresh-cut
2. Internally rounded form
3. Sufficient Depth
4. Consistent Depth
5. Mechanically efficient Interlocks with Resin

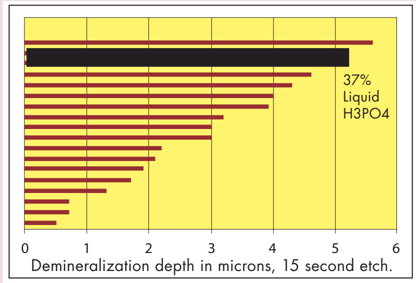

TABLE 1—Efficacy of etchants, from Summitt & Robbins.[3]

TABLE 2: TANGENTS OF BEVELS

Angle (Degrees)	Tangent
6	0.10
11	0.19
30	0.57
45	1.0
60	1.73

2. ENAMEL AXIOM #2: ALWAYS BOND ROD-ENDS

This resistance of rod sheaths to acid dissolution by virtue of the arrangement of the hydroxyapatite crystal lattice is nature's way of limiting lateral spread of caries. Resin technique must adapt to this biological "given". Acid etching progresses twice as rapidly on the rod end as on the rod sides.[5] Thus, to maximize effective bonding area in all prep designs, after eliminating the re-mineralized layer, one should expose rod ends either perpendicularly on flat enamel surfaces, or by a bevel that exposes rod-ends obliquely. This is represented schematically in Fig. 1 and Fig. 2.When this design criterion is met, acid dissolution doubles, resin penetration doubles, and adhesion doubles.

G.V. Black amalgam margins at 90 degrees to the cavosurface (butt margins) do not expose rod-ends, only rod sides. Occlusal margins, however, where the enamel itself is inclined, are intrinsically beveled in conventional Class I and II preparations.

A bonding agent typically delivering 35 MPa in laboratory declines clinically to 17.5MPa when mated to a 90-degree butt margin, where rods ends are not exposed. Aside from being less retentive, a butt margin may fail in two ways upon polymerization:

1. **Adhesive Resin Failure:** The restoration separates from the under-etched butt margin during polymerization; white line presents initially, and subsequent microleakage develops. This may evolve to brown line or other marginal stain.
2. **Cohesive Enamel Failure:** The restoration adheres to the immediate enamel, but because contraction is not dissipated into multiple rods, stress concentrates along a single plane of rods. When this stress exceeds the inter-sheath cohesion, enamel 'peels' between contiguous rod sheaths. This may be visible immediately after placement as white line, and/or may evolve also to brown line. This is schematically illustrated in Fig. 3

Both modes of failure fail esthetically, and also risk recurrent decay or restoration loss. A beveled margin overcomes these risks.

3. ENAMEL AXIOM #3: ALWAYS A BEVEL

Definition of a bevel: A composite bevel is defined as a continuous and oblique divergence from the DEJ. The angle is included between a baseline A, lying parallel to the enamel rods, and cut line B, the plane of the bevel. Fig. 4 illustrates the bevel on a lingual shoe margin on a maxillary incisor.

This concept is distinct from a partial bevel, proposed by some authors and taught in some dental schools, placed as an afterthought near the cavosurface on a margin that is still principally 90 degrees. For the histological reasons cited above, enamel rods are better continuously transected from the DEJ to the cavosurface.

4. ENAMEL AXIOM #4: MARGIN EXTENSION FOR THICKNESS TO PROLONG LIFESPAN

The clinical wear rate of teeth in occlusal function differs from patient to patient, but research indicates an average rate of 30 microns per year.[6] Thus, an occlusal thickness of one millimeter of enamel may be expected to endure about 33 years. As we are scarcely 20 years into the resin restoration era, ultimate lifespan of resin restorations is still conjectural. However, if enamel is less than a half millimeter in thickness, particularly in areas of attrition, clinical service may end prematurely by broaching through either resin or enamel into dentin. See Figs. 5 and 6. The Brinnell hardness of enamel is 9.8, while that of most hybrid resins is about 8.5, and dentin, 6.8. The Brinnell scale, being logarithmic, means that the wear of exposed dentin may be 1000 times greater than enamel. Replacing exposed dentin with hybrid resin increases hardness nearly 100-fold. While research

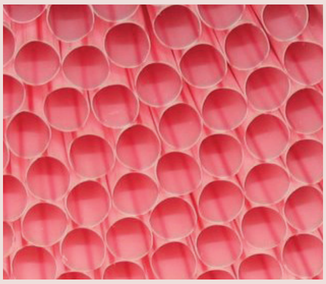

FIGURE 1—Schematic: fresh-cut enamel rod ends on flat surfaces.

FIGURE 2—Schematic: enamel rod-ends exposed with a bevel.

FIGURE 3—Schematic: enamel rod sides suffering cohesive destruction after polymerization.

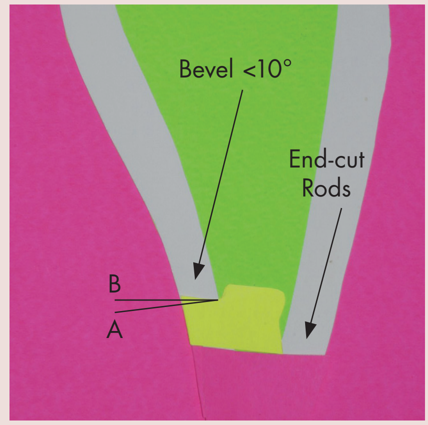

FIGURE 4—Enamel design on lingual margin of worn maxillary incisor.

FIGURE 5—Premature failure of under-extended restorations.

FIGURE 6—Restorations in deep overbite/GERD/unilateral Bruxer. Depth increased and cavosurfaces extended to increase lifespan and marginal thickness.

shows that current resins often wear at rates no more rapidly than enamel, they are still nearly ten times softer. Consequently, clinical prudence is indicated in wear-prone locations: outlines should be extended to arrive at a more useful enamel thickness of 1 mm, so that wear will not penetrate through enamel prematurely. This may often invoke only a minor extension beyond a wear facet, for example.

#5. ENAMEL AXIOM #5: MARGIN EXTENSION TO RESIST CONTRACTION

Margin extension may also be required is to engage thicker enamel, i.e., to provide enough beveled rod-ends to dissipate contraction forces. Very thin enamel encircling large masses of resin may suffer contraction damage, in the form of crazing or cohesive marginal failure, if this is not implemented. Extension to engage thicker enamel makes finish lines more robust. See Fig. 7.

BEVEL CHOICES: WHICH BEVEL IS BEST?

Long bevels, ie. 60 degrees or greater, are accepted as a method of esthetically matching resins to tooth structure. Paired to suitable resins, long bevels do successfully produce invisible margins, and also meet the above enamel axioms, being fresh-cut and exposing rod-ends. Equally, 45 degree bevels, once considered ideal at the outset of the composite era, also meet these criteria. But both of these extensive bevels are clinically more destructive than desirable from the perspective of Minimally Invasive Dentistry. But if a resin is opaque, as many posterior resins are, long bevels do not improve cosmetics. Also, in some low-visibility locations, such as mandibular molar lingual shoed cusps, esthetic prominence is so low that a long bevel is pointless except for the most demanding of patients.

The literature offers limited evidence guiding the lower limit of bevels for functional margins. What is the least bevel that will expose enough rod ends while sacrificing the least tooth structure? Over time, in our study club, searching for the least bevel that was still reliable, the clinical conclusion emerged that a very slight bevel, less than ten degrees, was stable and often very esthetic. For example, Fig. 8 illustrates five-year results of four Class V abrasion lesions prepared with an occlusal bevel of less than 10 degrees. The resin, Tokuyama Estelite Sigma A3.5, overlies Danville Starflow A3.5 placed thinly on the unstained dentin and along the gingival cavosurface. The success of this minor bevel is due to the resin's metamerism. When high esthetics derive from the resin, not the preparation, minimal bevels can be both functional and esthetic. Another case, Fig. 9 illustrates similar outcomes with 3M Espe Filtek Supreme Plus Body A3.5 over Danville Starflow A3.5. In these instances, the bevel enlarges the facial footprint by only one tenth of a millimeter, relative to a butt margin, and engages approximately 20 rod ends in so doing. How was this calculated?

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FIGURE 7—Class II deep overbite, facial attrition: 7406 bur placing perimeter bevel, and extending oblique wear facet towards gingival margin for thickness.

FIGURE 8—Four maxillary Class Vs with below-ten degree occlusal bevels. 5-year post-op.

FIGURE 9—Two maxillary Class Vs with below ten-degree occlusal bevels. 5-year post-op.

FIGURE 10—200 rods are found on each side of a square millimeter of enamel.

FIGURE 11—7406 12-bladed finishing bur (Beaver Trucut) imparting under-ten degree bevel to lingual margin of maxillary incisal margin.

FIGURE 12—7406 bur planing and beveling occlusal margin on Class V.

FIGURE 13—Typical irregularities after preparation with a 330 bur.

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GEOMETRY MEETS HISTOLOGY

Enamel is composed of 30,000 to 40,000 enamel rods per square millimeter of tooth.[1] The number of rods in one linear millimeter of enamel is found by taking the square root of 30,000 and 40,000, namely, 173 to 200 rods per millimeter, Fig. 10 . Thus, when a bevel removes one-tenth of a millimeter at the cavosurface, approximately 20 enamel rods are transected. To calculate the angle of the bevel, the tangent function of the bevel is required. From Table 2, a bevel of 6 degrees, whose tangent is 0.10, cuts one tenth of a millimeter at the cavosurface (assuming an enamel thickness of 1 mm.) An eleven-degree bevel, whose tangent is 0.19, approximates a cavosurface loss just under two-tenths of a millimeter, i.e., 38 rods.

In study club, predictable and stable enamel margins have been clinically achieved using bevels between 6 and 11 degrees- i.e., a cavosurface increase in footprint of only one to two-tenths of a millimeter, assuming enamel 1mm thick. This has become the conceptual design for a minimum bevel in our study club technique. Esthetic blending with his bevel depends heavily on resin properties, but clearly can be excellent, Figs. 8, 9. The clinical case volume includes many thousands of restorations, and a time span beyond a decade. Microleakage studies are now an essential step to validating the freedom from clinical defect routinely seen with this bevel.

Contrast this with a 45 degree bevel, considered ideal for a Class V occlusal margin at the start of the composite era.[1] The tangent of 45 degrees- an isosceles triangle- is 1.0, which entails an increase in the enamel footprint of 1 millimeter, which transects 200 rods. At ten times greater enamel loss, this appears to be a heavy and

FIGURE 14—7404 to instrument cavosurface in smaller preps.

FIGURE 15—Poor long-term performance of long occlusal bevel.

FIGURE 16—Funnel-like extension on cusp tip to extend past zone of gnarled enamel.

FIGURE 17—Cusp tip showing friable gnarled enamel.

FIGURE 18—Cusp tip preparation with facial bevel less than ten degrees.

FIGURE 19—Finished restoration of cusp tip, 18 months post-op.

clinically avoidable price to pay.

MINIMAL BEVEL INSTRUMENTATION

In study club, a variety of burs were experimentally utilized to prepare minimal bevels, but instrumentation has now settled on three burs. If a very light bevel is needed on thin structure, a Beaver Trucut 7902 flame-profile bur is used. Its small diameter dictates that it will not readily overcome irregularities and unify the cavosurface into a clean linear finish line. However, it will prepare minor extensions effectively and conservatively.

Where unification of irregularities is needed, a Beaver Trucut bullet-nosed 7406 12- fluted finishing bur is used instead Fig. 11. After cavity walls are cut with a fissure bur to butt margins, the 7406 bur is used to plane and bevel the cavosurface. Smaller preps may require another bur, the Brasseler 7404. Note that it is egg-shaped and the shank is not gold-plated, conveniently distinguishing it in bur set-ups from the gold-shank 7406.

These are unusual applications for these burs, which more often are used for shaping and finishing. But the 7406/7404 burs have large diameters and 12 unaggressive low- rake blades, which smoothly plane enamel, unify marginal irregularities generated by typical smaller-diameter operative burs, and simultaneously bevel the cavosurface. Note that the shape of these burs vary by manufacturer. The Beaver Trucut 7406 has parallel sides in its upper profile which will bevel enamel by simply angling the handpiece. Most other 7406 profiles are egg-shaped and will undermine enamel past the height of the bur's contour. The Brasseler 7404, besides its visual distinction, has a smaller diameter and greater nose taper than the equivalent Beaver Trucut 7404. Its application is to shallow, smaller preps with thin perimeter enamel. This lessens axial penetration sp that its undermining egg shape does not come into play.

In a controlled fashion both 7406 and 7404 burs establish bevels that are dependent primarily on the depth of penetration of the bur. In both instances the taper produces a more generous bevel in shallower enamel. This beneficial correlation exposes and engages greater numbers of rod ends to dissipate contraction forces when the enamel periphery is thin. To illustrate the use of the 7406 on flat-surface preparations, the preparation sequence for a Class V will be described, where enamel thickness is typically 1mm on the occlusal margin, and less at the line angles.

ILLUSTRATION; CLASS V PREP:

Initial outline for a Class V prep is developed with a 330 FG bur. The 1.8 mm dentate portion of the bur guides axial penetration and thereby prevents axial overcutting. Its small diameter (0.78mm) confers delicacy, light touch, good tactile feedback, and conservative removal. However, due to its inverse taper, all margins will be slightly undercut after outline form is established. To correct

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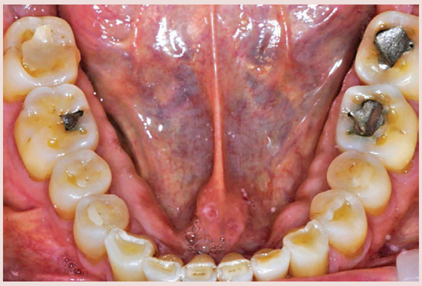
FIGURE 20—Mouth with multiple molar and bicuspid cusp tip defects.

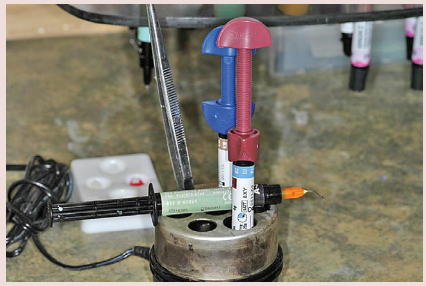
FIGURE 21—Addent composite heater showing method for heating hybrid and flowable.


FIGURE 22—Increased plasticity after heating resin. Example: 3M Espe Z-250.


FIGURE 23—Sharp fractured edge on mandibular incisor.


FIGURE 24—Fractured mandibular incisal edge.


FIGURE 25—Lingual surface is sand-blasted inside a Tofflemire band, eliminating re-mineralized enamel and exposing rod ends.

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this, the 7406 is placed in the cavity preparation at ninety degrees to the axial wall and is walked around the entire perimeter, Fig. 12. On thick enamel margins, it is held at an angle which bevels the enamel slightly by one to two tenths of a millimeter - 6 to 11 degrees. On thinner enamel, the taper of the bur increases bevel automatically as bur penetration decreases. On all margins, and on the gingival margin, even if in cementum, a cleaner margin results from planing irregularities typically remaining after the 330 bur. Fig. 13 In small preps, the smaller 7404 bur is more suitable, Fig. 14.

As one proceeds around the preparation perimeter, this bur develops external line angles with a more generous radius. Submarginal deficiencies in placement are therefore less likely, as placement is improved by generously radiused line-angles. These also finish better in composite compared to tightly-radiused line angles. Finally, rounded external line angles have a more esthetic appearance.

The resulting occlusal margin is sharp. Such a margin is easier to locate and finish than a long bevel margin, because a more definitive finishing end-point is found. Consistent resin thickness at the occlusal margin is more stable clinically than long bevels, which are prone to chipping and uneven wear, especially if abfraction forces are present. Fig. 15

One might ask, why not use a large diameter tapered operative bur, such as 700 or 1170 family, which are already at 7 degrees taper, i.e., very close to the desired outcome. This was our initial choice in study club, but operative burs have six blades with more aggressive blade rake, a smaller diameter, and end-cutting qualities. Overcutting, both in axial depth and outline form extension can therefore quickly occur with a large diameter tapered operative bur. A fine diamond can overcome this drawback, but leaves a microscopically irregular margin, which is harder to seal. The bulletform 7406 carbide is less aggressive and not appreciably end-cutting, and, with a 1.8 mm. diameter, most effectively unifies marginal irregularities to a razor-sharp line. Large operative burs of similar diameter, such as an 1172 bur, at 1.6mm, require extraordinary operator control to be safe.

The converging bullet-form shape of the 7406 automatically increases bevel in shallow preps, which cannot be said of tapered operative burs. For a tapered operative bur to achieve the same effect, the handpiece has to be progressively tilted as axial depth decreases. This may be ergonomically difficult in tight buccal and lingual corridors. The simplicity of walking the 7406 bur around

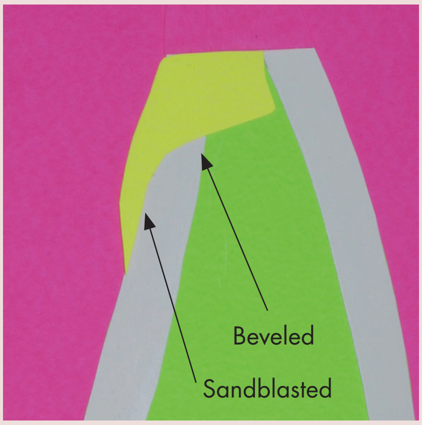

FIGURE 26—Schematic of preparation design for linguo-incisal restoration of mandibular incisor.

FIGURE 27—Typical clinical result of linguo-incisal restoration of mandibular incisor. Over-contouring of lingual surface is discreet.

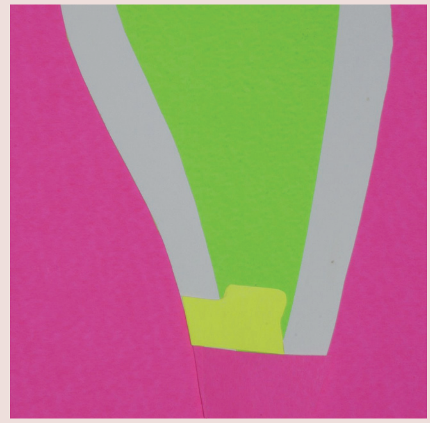

FIGURE 28—Schematic of maxillary lingual shoe prep design.

FIGURE 29—Preparations showing consistent depth.

FIGURE 30—Post –op restorations showing consistent esthetics. 21 was deepened relative to 11 to hide dentinal stain.

FIGURE 31—Post-op showing harmonization of shade between central incisors .

the enamel periphery, at 90 degrees to the cavosurface, and letting the bur shape accomplish the bevel, according to the axial depth of the prep, without concern for axial over-penetration, is a welcome convenience to the operator. Finally, in many offices, bullet and egg-form burs are used for finishing and shaping, and a further use for margination represents efficient and multiple-purpose instrumentation.

CLASS V OUTLINE FORM

The best esthetics will result if the occlusal margin is perpendicular to the long axis of the tooth mid- buccal, and if the line angles of the preparation are raised in a gentle curve in a "smiley" outline form. Our study club experience has been that the gingival margin shows the best resistance to re-decay if placed a half-millimeter below the gingival tissue in the "caries-protective zone". The use of epinephrine-containing retraction cord ensures this relationship to tissue if the gingival margin is prepared exactly to the retracted tissue line. When the tissue rebounds post-operatively, the gingiva will cover the restored gingival margin. A high polish, low exit angle, precisely finished margin without overhang or deficiency are all essential. Finishing methods also must not violate the junctional epithelium, as recession may ensue, effectively lifting the margin post-operatively out of the sulcus.

THICK ENAMEL

While a 6 to 11 degree bevel generates a stable enamel cavosurface outline form for most enamel margins a millimeter in thickness, in thicker enamel (>1mm) a lesser bevel might conceivably engage the requisite limited number of rod-ends. However, distinguishing clinically between bevels on thick enamel of 6 degrees versus perhaps 3 degrees becomes rather moot.

CUSPIDS: NEAR THE CUSP TIP-GNARLED ENAMEL

As cuspid tips are approached, the orientation of enamel rods often becomes irregular. The term "Gnarled Enamel" is applied to this histological feature. 7

In the study club, we have found that clinical longevity in a loaded cusp tip exhibiting friable enamel is improved if the bevel is generous, producing a funnel-like internal form as in Fig. 16, using the 7406 or 7404 bur to extend the resin margin past the zone of gnarled enamel, Figs. 17,18,19.

MOLARS AND BICUSPIDS – CUSP/OCCLUSAL ATTRITION DEFECTS

Occlusal attrition-related defects

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FIGURE 32—Preoperative view of maxillary incisors showing staining and chipping of buccal and lingual margins.

FIGURE 33—Dentinal staining on lingual surface.

FIGURE 34—Preparation with lingual bevel made with 7406, labial bevel with 7902, both under ten degrees, and sandblasting of all enamel surfaces.

FIGURE 35—Lingual view of restored case, Tokuyama Estelite A3.5.

FIGURE 36—Facial view of restored case.

FIGURE 37—Prototypical incisal preparation showing efficient dentin interlock. Incisal 0.5mm is bonded to rod-end enamel; gingival 0.5 mm is interlocked with dentin and bonded.

FIGURE 38—Typical incisal preparations, 1.0 to 1.2mm deep. Facial, lingual, and proximal dentin is not undermined. 7902 slight bevel on lingual overlays, enamel sandblasted.

FIGURE 39—Typical sextant of incisal and inciso-lingual restorations, 5 years post-op. 37% Liquid Phosphoric acid etch 15 seconds, Danville Microprime B, Kuraray Photobond, Tokuyama Estelite Sigma A3.

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in molars and bicuspids are often seen in posterior teeth on inclined planes near cusp tips, Fig. 20. This clinical entity, common even in young patients, is now attributed to acid erosion as a co-factor in addition to excess occlusal loadings. This etiology requires eliminating dentin exposure to acid dissolution and restoring the enamel defect to full occlusion. Such defects restore poorly with a fissure-bur preparation alone. Likely due to the presence of gnarled enamel, it is more successful with a preparation similar to the above design for cuspid tips. To increase service life and retention, the initial preparation is deepened into dentin with a 330 bur, and widened until enamel of sufficient thickness is achieved. If a funnel shape is deemed too destructive, the sub-occlusal surface may be sandblasted at the form already generated by occlusion (fresh-cut), and the enamel overlaid (end-bonded) with resin.

RESIN SELECTION FOR INCISAL ATTRITION AND DEFECTS IN OCCLUSAL CUSPS AND CUSPID TIPS

It is critical to these restorations that a small-particle, fluid resin with good wear properties and low contraction be selected. Most resins can be improved in fluidity by heating with composite heaters such as manufactured by Addent Fig. 21, or HNI, or by microwaving the compule or syringe. The effects of heating are all in a positive direction: greater hardness, more rapid cure, higher photo-conversion and thinner oxygen-inhibited layer all result.[8] Frequent re-heating has been shown to have no effect on resin life in syringe or compule.[8]

A few manufacturers have promoted the use of flowables for these restorations, showing reasonable in vitro wear rates, but this has not been clinically validated. Generally, a higher particle load generally correlates with longer wear. Filler loading is usually at least 20% greater in hybrids relative to flowables. Contraction stress in these high C-factor preparations is undesirable, and polymerization contraction is nominally higher in flowables, averaging over 4 percent. Ultimate stress to tooth structure can be offset to some extent in flowables by lower flexural modulus, and by proprietary formulations.[9] However, lowering modulus imparts a structural penalty, viz., reducing rigidity in supporting the fragile enamel perimeter. Excellent final resins with less than 2 percent contraction and modulus approaching dentin are available. Heating these resins increases plasticity and adaptability for small restorations, Fig. 22, reducing flaws in placement as easily as with flowable. For these reasons, heated hybids are generally preferable to flowables. Fissurotomy restorations similarly endure better with heated hybrids rather than flowables, using suitably small condensers to ensure proper adaptation.

FIVE DENTIN AXIOMS: OPTIMIZING DENTIN ADHESION

The dentin aspect of preparations provides less choice to the operator than the cavosurface, being driven by caries, access considerations, visualization requirements, dimensions of placement instrumentation, handling properties of resins, and other technique factors.

Acid-etched dentin increases far less in area than enamel: only 150% to 400%, depending on site. Outer dentin, comprising 4 percent tubules, may gain 400% in surface area from etching. Near-pulpal dentin, comprising 80% tubules, gains far less. Within root canals, intracanal dentin area increases from150% to 250%, depending on depth of the canal and age of the root.[3]

DENTIN AXIOM #1: ALWAYS FRESH CUT OR AIR - ABRADED

This removes biofilm, etch-resistant fluoridated dentin, and hyper-mineralized sclerotic surfaces.[10] As with enamel, removal of only microns is required.

DENTIN AXIOM #2: ROUNDED FORM, STRESS RISERS

Rounded internal line angles: Transitions from one plane to another should be rounded. Stress travelling within the resin, like flowing water, should not abruptly change direction over sharp internal form. This compares to the turbulence of a stream flowing over and around rocks: smooth, laminar flow is preferable. In a lingually-fractured mandibular incisor, the overlay onto the lingual surface of a mandibular lingual-incisal preparation is rounded. This transitions the lingual resistance buttress smoothly into the dentin dovetail. Figs. 23-27.

Elimination of stress risers: Sharp internal form, such as seen after tooth fracture, Fig. 22, must be eliminated.

This structural principle is widely honored in diverse engineering applications, from soda cans to airplane wings. Where will a pop-top soda can open? - Along the line scored around the lifting ring. Comparably, in aircraft, a tiny nick in the wing surface mandates panel replacement. Any flaw in a continuous surface becomes an axis around which repeat flexure takes place, leading to localized fatigue and material failure. As the flexural modulus of most current resins is from to 8 to 14 gigapascals, compared to the flexural modulus of dentin, 14 to 22 gigapascals, and that of enamel, 80GPa, and resin is the more fluid element in tooth/resin interactions. Because the flexural strength of most hybrids ranges from 85 to 170 Megapascals, compared to dentin at 220 MPa, resin will be the element moving the most. Being the weakest in load-carrying capacity, it is likely the first to fail, and fracture will initiate around a sharp internal form.

DENTIN AXIOM #3: CONSISTENT DEPTH FOR AESTHETICS

When treating visible surfaces, consistent penetration along the incisal surface leads to consistent aesthetics. Just as in laboratory ceramics, direct materials need room to develop aesthetics. In outer dentin, pulpal encroachment is of no concern, but stained tooth structure needs depth of overlying resin to be effectively hidden. Figs. 28-36 illustrate maxillary linguo-incisal preparations following this principle.

DENTIN AXIOM #4: SUFFICIENT DEPTH TO ACCEPT LOADS

In structures such as a beam, the strength increases as the square of the depth. Shallow restorations that receive measurable loads, for example, maxillary inciso-lingual restorations, may fail at the lingual resin-enamel margin due to insufficient depth. This is where the strain between lingual compression and the flexural shear in the dovetail meet. A material path in the prep must be provided, of sufficient depth and volume, through which these strains can travel and resolve. Clinical experience and judgment informs the spatial need from case to case, according to the resin selected. Because performance varies as the square, small increases in size can pay large dividends. The parameter of flexural strength governs outcomes greatly, and varies from 85 to 172 Megapascals, i.e., over 200%, in hybrid and nano-hybrid resins. Therefore, different outcomes will be seen in similar preparations if different resins are placed.

DENTIN AXIOM # 5: MECHANICALLY EFFICIENT INTERLOCKS

Adhesion to dentin generally declines over time, so that efficient macro-retentive features such as dovetails and parallel or convergent walls can supplement adhesion and improve durability.

Mechanical interlocks improve stress transfer from dentin to the restoration and reduce cyclic fatigue at the adhesive interface as it ages. A clear example of form sparing the bond is seen in the prototypical simple incisal preparation, Figs. 37-39, made to a depth of 1 mm. with a FG 330 bur.

CONCLUSION

Our study club has found that the preceding principles ensure long clinical life and trouble-free service in ways that might have seemed impossible early in the adhesive era. For example, over 3000 restorations of incisors in various configurations over a twelve year span have been maintenance-free in the author's practice. These restorations have reduced the rate of wear, improved cosmetics, and prevented further enamel ablation. A large number of dentate older adults in private practice now need this service.

While preparations can be standardized, treatment outcomes still vary enormously if different etch, adhesives, and resins are used. Being primarily invisible and informationally complex, product claims are subject to commercial distortion and illusion. Further crucial chairside variables such as curing,[11,12] and the need for perfect isolation, continue to make composite technique one of the most inconsistent and complex areas of dentistry today. **OH**

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Oral Health welcomes this original article.

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