Adhesive Preparation Technique: Angles and Aesthetics

By Dr Gary Unterbrink

The original “adhesive” preparation technique as described in the literature was proposed prior to the introduction of effective dentin bonding agents. It had nothing to do with adhesion, but was based primarily on geometry (Luescher). The combination of beveled margins and undercuts utilized shrinkage to improve marginal adaptation, analogous to placing a rivet in steel beam constructions. In fact, the classic “adhesive preparation technique” relied on internal gap formation to improve marginal adaptation, which in turn frequently led to postoperative sensitivity.

While the bond to dentin is important to reduce postoperative sensitivity and the risk of secondary caries at dentin margins, the bond to enamel is much more important to achieve a stable esthetic result. Unfortunately, many aspects of preparation for conventional restorative techniques have simply been transferred to adhesive techniques, without questioning their validity for new materials.

Two interactive factors should be mentioned in relation to preparation technique. Bonding materials have reduced the requirement for mechanical retention. Metal-free restorative systems also open new possibilities: the elimination of metal with its requirement for opaquers contributes to a reduced need for deep preparations, and supragingival margins can be used without aesthetic compromise.

Investigations have shown that margin form and preparation depth do not influence the strength of bonded full ceramic crowns (Meier, Fenske, Bernal, El-Mowafy, Wiskott). Note that conventionally cemented metal-free restorations still require a shoulder. We will come back to crowns later, but begin with some general principles.

Bevels

The literature is ambiguous in relation to bevels on margins, in particular for occlusal surfaces. Clinically, margins are beveled for three main purposes:
  • to contribute to retention: increased enamel bond surface area
  • to reduce microleakage: bevels more frequently cut across prism ends
  • to improve esthetics: softening the transition from tooth to restorative material

It could be noted that the placement of bevels for cast metal restorations is done to help compensate for dimensional variation of impressions and models, but this also fits into the category of reducing microleakage.

The angle of a bevel is important for the etch pattern and bond stability, the depth of a bevel is the primary determinant of strength in relation to retention, and the length of a bevel the most important factor for esthetics. However, we probably should not even use the classic term „bevel” in relation to adhesive dentistry, but would more correctly speak of preparation angles and margin forms.

Bonding to enamel

Bonding to enamel is taken for granted; simply etch, rinse, and apply the bonding agent.
However, if it was really this simple, we would not see so many “adhesive” restorations with discoloured enamel margins. The etching and rinsing times (a number of publications would indicate that an etching time of 30 seconds will reduce variability compared with 15 seconds), the resin application technique (rubbing the etched enamel with a brush can destroy the fragile etch pattern), the contact time (at least 20 seconds should elapse before light polymerization), the influence of the bonding agent primer on enamel bonding (thick layers of hydrophilic primers can lead to problems with bond stability), and the variations of the question “How wet is damp?” can all influence our result.

Nearly all bond strength testing is done under ideal laboratory conditions with the preparation nearly perpendicular to the prism direction. We know that we need to cut across the prisms to get a reliable bond. But what are the correct angles? In most textbooks, enamel prisms are drawn perpendicular to the surface. While this is true for some areas of the teeth, it certainly is not correct as a general rule. Prisms reach the DEJ at approximately 90°. Here we can see bond strengths measured perpendicular and parallel to the tooth surface (Carvalho, Ikeda). The prism orientation in the areas of the bonding are shown with the black lines. Note that the parallel bonding surfaces do cut the prisms at an almost ideal angle, but the perpendicular samples still cut across some of the prisms due to the curvature of the prism rods. A preparation truly parallel to the prisms can result in a bond strength approaching zero, and the clinical result is a gap and a stained margin. If the preparation undercuts the prisms at the margin, the immediate result is a white margin, which generally stains and fractures over time.

Considering the importance of enamel prism orientation in adhesive dentistry, it is surprising how little attention has been paid to this aspect of preparation technique (Munechika, Rasmussen, Osborne, Pinheiro).

Posterior restorations

Occlusal Margins / Onlays
On the occlusal surface, from the fissure area out to about 1.0 mm from the cusp tips, the prisms at the surface demonstrate an angle of 60-65°, as can be seen in the previous graphic. This is valid for all posterior teeth (Uriba). The correct preparation angle therefore depends on the angle of the cusp slope, a general recommendation for divergence of inlay preparations is therefore not possible. Here in particular the word “bevel” is completely inappropriate. On the occlusal surface, one can use the following idea for orientation. Imagine a right angle to the cusp slope, and try to bisect this angle with the preparation.

Another way to express this (see below) is that one desires a 45° angle in the restoration margin (an angle of 135° in enamel).

On teeth with flat cusps, for example the typical upper second molar, you have to find a compromise between the preparation angle and the extension of the cavity.

The following computer graphic (see next page) represents a “simplified average” for the outer enamel surface on vestibular and oral surfaces, proximal surfaces are very similar.
A preparation at the angle of the red lines will provide a good etching pattern and bond, but blunt margins tend to cause aesthetic difficulties, in the occlusal and middle thirds of the tooth a bevel can be prepared to soften the transition and improve aesthetics. This aesthetic modification is really only required for extremely demanding patients or maxillary premolar buccal cusps.

Finish lines on the cusp tips are a problem, since the prisms in this location are nearly vertical. With laboratory fabricated restorations (inlays), as opposed to direct restorations, the chance that these margins will be esthetically stable increases but it is still preferable to avoid any margin at a cusp tip.

The lack of bonding if the preparation is parallel to the prisms is one explanation for the nearly equivalent incidence of cusp fractures with “bonded” composites and amalgam with intracoronal restorations (Wehr).

Clinically, direct composites also show better long term survivability if all thin cusps are onlayed. Clearly more onlays should be prepared for both direct and indirect restorations (Benedicenti, Opdam). In general, the cusp should be reduced approximately 1.5 mm. As the preparation margin moves gingivally, the angle of the preparation is increased.

**Gingival margins**

Prisms in cervical enamel demonstrate a fairly wide variation, but in general are perpendicular to the surface or angled slightly down. Margins in cervical enamel should be "beveled" to improve the etch pattern (Lutz, Hinoura, Halter, Cheung, Loesche, Opdam).

Although I prefer a higher angle with direct restorations, approximately 45°, the dental technicians prefer 20-30° for indirect techniques. Steeper angles make the laboratory work more difficult, especially with ceramic – talk to your technician! A properly fitting inlay also reduces the requirement for an optimal bond, so some compromises are permissible.

**Proximal Boxes: Axial Walls**

When I look through the models in a typical dental laboratory, this aspect of the preparation is frequently incorrect. The easiest way to imagine the angles of the prisms on these walls is an idea I have adapted from Prof. Alan Boyd of London. Think of a point in the center of the tooth, and lines radiating out from this point. This corresponds reasonably well to the average prism direction. (Note: Decussation is particularly prominent at the transition zone from proximal to lateral surfaces.)

The preparation should cross these lines from the inside to the outside, or at least be parallel to them. With laboratory techniques you have a bit more freedom, since shrinkage stress is minimized.

**Anterior restorations**

The prism orientation with anterior teeth corresponds roughly to individual posterior cusps. The prisms curve strongly toward the incisal
edge in the incisal 1/3, and become approximately perpendicular to the surface at the junction of the middle and cervical thirds.

As with posterior teeth, at the cervical margin the preparation is angled down at 30-45°. If the incisal edge is strong enough with a small to medium Class 3, a horizontal internal preparation permits reverse etching. On the palatal, the vertical margin is “beveled” at about the same angle as the cervical. Labially, long bevels are usually placed to improve esthetics.

With direct restorations, I prefer to prepare what I call a “wave bevel” on the labial. This is a part of the concept of “aesthetic camouflage”, the eye does not see a curved line at the margin as easily as a straight line or smooth curve.

Shade Selection and Restoration

Cervical Shade

Incisal Shade

Crown preparations

Crowns are the restorations of last resort, and crown preparations should only be performed when more conservative treatment is impossible. Conventional full crowns are perhaps the most overprescribed treatment in dentistry today. Adhesive techniques can provide significant advantages, but traditional treatment modalities seem to be particularly well entrenched in prosthodontics.

Posterior teeth with intact buccal and lingual enamel, and a wall thickness of 2 mm or more at the cervical aspect should not be crowned, an adhesive onlay is the preferable method for restoring these teeth (Krifka).

Anterior teeth which do not demonstrate caries on the palatal surface, i.e. the majority of them, should not be prepared on the palatal to the gingival margin, the palatal margin should be placed on the cingulum (Magne). The following clinical example demonstrates this.

Despite the requirement for endodontic treatment and a glass fiber post on the right central incisor, the palatal margin of the final preparation simply encompasses the endodontic access opening. Extending this preparation to the gingival margin is clearly not necessary for an adhesively cemented restoration.

When crowns are unavoidable, research has also shown that adhesively cemented full ceramic crowns require less axial preparation than conventionally cemented metal-ceramic crowns (Meier, Burke, Kelly). The advantages are clear: the tooth is more fracture resistant cervically and the risk of endodontic complications is reduced (Edelhoff).

All crown preparations require an anatomic reduction, with adhesively cemented full ceramic crowns this can be as little as 0.6 to 0.8 mm., and this is valid for anterior and posterior teeth. An incisal reduction of anterior teeth of 1.5 mm is frequently recommended, although this is
almost never correct. In fact, any standard value for incisal reduction is nonsense, the anatomic axial reduction of the oral and vestibular surfaces, followed by rounding any sharp angles, automatically creates the proper reduction for that particular tooth. (This is incidentally on average 3-4 mm with maxillary anterior teeth.) Straight labial preparations (i.e. non-anatomic) and underpreparation of the incisal edge is an extremely common mistake; leading to overcontoured and often opaque crowns and/or traumatic occlusion.

Here we see the replacement of a metal-ceramic FPD with e-max full ceramic. The main cause of the poor aesthetics was a non-anatomic labial preparation.

Conclusion
Adhesive dentistry is not simply the substitution of bonding agents and composites for traditional dental materials: the optimal preparation techniques differ dramatically in relation to margin position and geometry. In many clinical situations, we can provide restorations which are functionally and aesthetically better than conventional dentistry, bringing us slightly closer to the goal of “nihil nocere”.

Literature


Gary Unterbrink graduated from dental school before completing mandatory military service in an Army dental clinic in Germany. Gary then spent three years working in private practice in Regensburg, then a year at a government clinic in Austria. Fifteen years with Ivoclar-Vivadent followed, including positions as director of clinical research and later, director of professional services. In 2001, Gary joined a former department employee in private practice in Liechtenstein, while continuing to lecture. Gary has delivered more than 5,000 lectures in more than 60 different countries.