ADHESIVE DENTISTRY

The Step-by-Step Workflow

Adriano F. Lima, DDS, MS, PhD

QUINTESSENCE PUBLISHING

Adhesive Dentistry: The Step-by-Step Workflow

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FOREWORD

by Markus B. Blatz, DMD, PhD, Prof Dr med dent habil

For his book, Adriano Lima has assembled the "who's who" in current adhesive dentistry to not only demonstrate state-of-the-art and up-to-date clinical protocols with stunning documentation but also provide a deep dive into the current scientific literature, providing sound evidence and rationale for these procedures.

Adhesive dentistry has evolved from a promising innovation to the cornerstone of modern restorative practice. Yet with this evolution comes unprecedented complexity. Today's clinician must navigate an expanding landscape of materials, techniques, and protocols—each decision carrying significant implications for treatment longevity and patient outcomes. The question is no longer whether to bond but *how* to bond optimally for each unique clinical scenario.

What distinguishes this textbook is its pragmatic approach to addressing the real questions clinicians face daily. Should this restoration be repaired or replaced? Which adhesive protocol suits a deep cavity preparation? How should we approach selective caries removal near the pulp? These are not theoretical exercises but genuine clinical dilemmas that directly impact our patients' oral health. Dr Lima and his distinguished coauthors have created a resource that bridges the often-challenging gap between laboratory science and chairside reality.

The clinical documentation throughout this volume is truly exceptional. Each case presentation reflects not only technical mastery but also the kind of thoughtful decision-making that separates adequate dentistry from excellence. The photographic quality and attention to procedural detail provide readers with clear visual guidance that reinforces the written protocols. This is clinical teaching at its finest—practical, precise, and thoroughly grounded in evidence.

Equally impressive is the scientific rigor underpinning every recommendation. In an era where marketing often overshadows evidence, this textbook stands as a model of how clinical practice should be informed by current research. The authors have meticulously reviewed the literature to ensure that each protocol presented reflects our best current understanding of adhesive mechanisms, material properties, and clinical performance. This commitment to evidence-based practice gives readers confidence that the techniques they learn will deliver predictable, durable results.

The organizational structure deserves particular mention. By progressing from fundamental concepts to increasingly complex procedures, the book builds clinical competence systematically. The inclusion of quick-reference tables and systematic protocol summaries makes this not merely a textbook to study but a practical guide to consult before and during procedures. This dual function—as both educational resource and clinical companion—addresses a genuine need in modern practice.

For residents, this book offers a comprehensive foundation in adhesive dentistry. For experienced practitioners, it provides the opportunity to refine techniques, update knowledge, and resolve uncertainties about emerging materials and methods. For all readers, it delivers clarity in a field often obscured by complexity.

Dr Lima and his coauthors have given the dental community an invaluable resource. This textbook will undoubtedly become essential reading for anyone committed to delivering contemporary, evidence-based restorative care. I am confident it will enhance your clinical practice and, ultimately, improve the outcomes you achieve for your patients.

FOREWORD

*by Patrícia N. R. Pereira, DDS, PhD**

Adhesive dentistry has become the foundation of modern restorative care. From the early days of acid etching to the multimode systems available today, the progress has been remarkable. These advances allow us to conserve tooth structure, deliver reliable function, and meet patient expectations for esthetics. At the same time, however, they have made clinical decisions more complex. With so many materials, protocols, and clinical situations to navigate, it is no longer enough to rely only on technical skill, making clarity and evidence essential for predictable results.

This is where *Adhesive Dentistry: The Step-by-Step Workflow* makes a real contribution. In this book, Dr Adriano Lima and collaborators organize adhesive dentistry in a way that is structured, approachable, and clear. The chapters move logically from the foundations of adhesion to the stepwise clinical workflows that guide daily practice. The style is clear and reproducible, with a focus on what matters most for the patient sitting in the chair.

The scenarios presented will feel familiar to every clinician. Direct restorations, for example, are among the most common procedures we perform, yet they come with critical questions: Should selective caries removal be used? What if the lesion is close to the pulp? Which adhesive strategy is most reliable for the substrate we are dealing with? How can we manage moisture to reduce the risk of postoperative sensitivity? These are the questions that shape clinical outcomes. By presenting evidence-based answers together with practical workflows, this book helps readers gain both understanding and confidence.

The same attention is given to indirect restorations. Deciding between veneers, onlays, or crowns is not simply a matter of preference; it requires evaluating substrates, choosing the right material, and selecting the appropriate bonding strategy. The book makes these choices easier to approach by combining illustrations, tables, and concise rationales. Challenging situations such as deep dentin margins, eroded or sclerotic surfaces, and noncarious cervical lesions are also addressed, with practical solutions that can be applied in everyday practice.

A consistent message throughout the book is that adhesive dentistry is more than a technique: it is a philosophy of treatment. Long-term success comes not only from selecting the right material but also from making thoughtful decisions, respecting biology, and carrying out each step with precision. That perspective is clear in the workflows, which are detailed enough to be reliable but flexible enough to adapt to the realities of clinical care.

One of the aspects I appreciate most about this work is its versatility. It can be studied systematically, used as a quick reference before starting a procedure, or consulted to confirm a specific protocol. The organization makes it practical for the student beginning to learn, the clinician who wants to refine techniques, and the educator looking for a structured way to teach adhesive concepts. It combines scientific accuracy with clinical applicability, and it presents adhesive dentistry in a way that is accessible, methodical, and useful for a wide audience.

It is a genuine pleasure to introduce *Adhesive Dentistry: The Step-by-Step Workflow*. I believe readers will find not only knowledge within these pages but also the reassurance and guidance to approach adhesive procedures with greater precision and predictability.

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Introduction

FROM PLANNING TO EXECUTION: THE HIDDEN CHALLENGES OF RESTORATIVE PROCEDURES

Adriano F. Lima

Tuesday. The first appointment after lunch is an emergency squeezed between regular appointments. A patient is complaining about dentin hypersensitivity following a composite restoration performed just a day earlier. Shortly after, another patient arrives reporting the debonding of a fiber post cemented a year ago, seeking help to address the issue. What a challenging start to the week!

The situations described above represent just two examples of the many challenges that arise in the daily practice of dentists working in restorative dentistry. While both scenarios could have been prevented, they are far from uncommon—even for the most experienced clinicians. But why do such problems occur?

Clinical experience and daily practice undoubtedly enhance your skills and efficiency, making treatments faster and safer. However, even for seasoned practitioners, skill and experience cannot replace a deep understanding of the materials and protocols involved. This knowledge remains critical to achieving long-lasting and predictable outcomes.

Take direct restorations, for example—perhaps the most frequently performed procedure in your practice. Although they may seem straightforward, achieving excellent results within a limited time frame can pose significant challenges. This is due not only to the detailed protocols required but also to the overwhelming variety of materials available on the market, each with its unique properties and indications.

Moreover, the constant evolution of materials and techniques adds another layer of complexity, demanding that clinicians stay updated to deliver the best outcomes. Without a clear understanding of these innovations, even minor errors can compromise the success and longevity of a restoration.

When planning a direct restoration, the first consideration is whether absolute isolation with a rubber dam is feasible. If it is, great! Humidity control—a crucial factor for adhesive procedures—becomes significantly easier to manage. But then come the next steps: Why is the restoration being performed? Is it due to a caries lesion? Should all the carious tissue be removed to reach sound dentin? And what if the lesion is close to the pulp? Should a selective caries removal approach be adopted? If so, how should it be done? Should carious dentin be preserved on all cavity walls? What happens in cases of pulp exposure? Which protocol offers the best chance for success in minimally invasive treatment to avoid endodontic therapy?

These are real and valid questions that arise before the restorative procedure even begins.

If the restoration is being performed to replace a previous, unsatisfactory restoration, another set of questions emerges. Should the entire restoration be removed, or is repair an option? What factors should guide the decision to repair versus complete removal? If repair is feasible, what is the best protocol? Should diamond burs or airborne-particle abrasion be used? Is it necessary to use the same composite as the original restoration? Should silane or adhesive be applied? If adhesive, which type, and how should it be cured? If complete removal of the restoration is required, does the adhesive protocol differ based on the depth of the cavity—shallow, medium, or deep?

The above questions highlight the complexity of what is often considered a "simple and straightforward" direct restoration. This procedure involves numerous decisions that directly influence not only the esthetic outcome but also the restoration's longevity and potential side effects, such as postoperative sensitivity.

For indirect restorations, the decision-making process can be equally, if not more, intricate. What type of indirect restoration is indicated—an onlay, overlay, laminate veneer, or full crown? What material should be used—composite or ceramic? If ceramic, which type—feldspathic, leucite-reinforced, lithium disilicate, or zirconia? Each type of ceramic demands a distinct bonding protocol. For example, how long should the surface be etched, or should it even be etched? Which acid and concentration should be used? Is the ceramic acid-resistant or acid-sensitive? Should silane or adhesive be applied? If adhesive, which system works best, and which resin cement—light-cured, dual-curing, or chemically cured—should be selected?

In cases of highly compromised tooth structure, the questions multiply. Should a post system be used? If so, should it be a cast metal core or a fiber post? What protocol ensures the best outcomes? Should adhesive or self-adhesive cements be employed? If using an adhesive system, is it compatible with the chosen resin cement?

Moreover, how can clinicians streamline these protocols without sacrificing precision, ensuring that their decisions lead to predictable and durable results? Addressing these nuances can significantly improve clinical outcomes and patient satisfaction.

All of these questions are real and must be addressed before performing an indirect restorative procedure. Each step directly influences the longevity of the restoration, particularly if an incorrect adhesive protocol is followed. It is because of these challenges that this book was conceived.

This book is designed to provide up-to-date and precise information on adhesive restorative procedures, grounded in the most current scientific literature. Considering the complexity of the field and the constant evolution of materials, this book delivers essential knowledge in an easy-to-navigate format, offering quick, straightforward explanations to guide the best choices for both direct and indirect restorative procedures.

With concise explanations of procedures and the critical questions they involve, this book helps you determine the best protocol to follow based on the procedure at hand and the materials available in your office. Additionally, you'll find tables that systematically organize detailed steps for various protocols, making consultation quick and efficient. This resource not only serves as a study tool for understanding diverse adhesive procedures but also provides key insights into achieving optimal tooth and gingival health while maximizing the longevity of treatments.

Moreover, this book is designed to be your reliable companion in the dental office. Whether you need a quick reference just before starting a procedure or confirmation of specific protocols, materials, or techniques, this guide ensures practical, fast, and trustworthy support.

The chapters are structured to build your knowledge progressively, starting with foundational concepts and advancing through increasingly complex procedures. By following the sequence of the book, you will gain a comprehensive understanding of adhesive techniques, enabling you to approach treatments with greater confidence, precision, and predictability. This structured approach ultimately leads to better control over procedures and enhances the longevity of restorative treatments.

Additionally, the book addresses common pitfalls and misconceptions, equipping you with strategies to avoid errors and improve patient outcomes. It also highlights the importance of staying updated with innovations in materials and methods, ensuring your practice remains at the forefront of restorative dentistry.

1

ADHESION TO ENAMEL AND DENTIN: RATIONALE AND PROTOCOLS

Leandro A. Hilgert and Adriano F. Lima

The possibility of adhering restorative materials to dental structures has revolutionized the dental practice. The development of adhesion has progressed hand in hand with the evolution of composite resins, the acceptance of a philosophy of minimal intervention, the understanding of the etiopathogenesis of major oral diseases (such as dental caries), and the emphasis on esthetics in restorative treatments. Today, the absolute majority of restorative procedures are performed, either directly or indirectly, with the aid of adhesive procedures that bond the restorative material to the remaining dental structure, without the need for extensive cavity preparations to achieve retention by means of a preparation's geometry. This allows for greater preservation of healthy dental tissue, leading to long-term maintenance of healthy and functional teeth.[1–3]

The origins of adhesive dentistry date back to the late 1940s when the chemist Oskar Hagger developed a product (Sevriton Cavity) that can be considered the first adhesive.[4] Shortly thereafter, in 1955, based on the observation of using acids to improve the adhesion of paints to metal surfaces, Michael Buonocore suggested acid conditioning of enamel to enhance the adhesion of acrylic resins to dental structures.[5]

Adhesion has evolved significantly, with different generations of materials and techniques in the subsequent decades. Enamel conditioning for anterior restorations with resins became well established among clinicians.[6] However, adhesion to dentin still posed significant challenges. The late 1970s stand out as a period of progress in this field, particularly with the work by Fusayama et al,[7] who suggested conditioning dentin with stronger acids (such as phosphoric acid, used for enamel). In the 1980s, the infiltration of resin monomers was described for dentin conditioning.[8] However, it was only in the mid-1990s that total acid conditioning of both enamel and dentin was widely accepted, and the understanding of the wet bonding technique[9] brought clinical success to adhesive systems. Now known as the *three-step etch-and-rinse* strategy, it involves separate steps for phosphoric acid, primer, and adhesive (resin bonding). Also in the 1990s, self-etch adhesive strategies were introduced to the market, eliminating the previous acid-conditioning step. Both strategies are still available today, with different commercial systems, degrees of simplification, advantages, and limitations.

In clinical practice, adhesive procedures are primarily performed on enamel and dentin, but they can also be applied on restorative material substrates such as resins, metals, ceramics, and glass-ionomer cements, among others. The aim of this chapter is to discuss adhesive interactions with enamel and dentin using the different adhesive systems available today.

SUBSTRATES

Adhesive procedures on dental substrates occur on enamel and dentin, which are structures with different compositions, and consequently, they present different challenges and require distinct steps to achieve good adhesion.

Dental enamel is a highly mineralized tissue composed of approximately 88% mineral (hydroxyapatite), 2% organic content, and 10% water (by volume). Laboratory studies and clinical follow-ups clearly demonstrate that well-executed adhesion to conditioned enamel is effective and long-lasting, and the presence of enamel at the margins of adhesive restorations contributes to greater treatment longevity.[10,11]

Dentin, on the other hand, has a different composition from enamel, presenting greater challenges and difficulties in adhesion. Dentin has approximately 50% mineral content, 25% organic content (especially type 1 collagen), and 25% water (by volume). In dentin, it is essential to understand the role of dentinal tubules, inter- and peritubular dentin, and the dentin smear layer in adhesive processes. Dentinal tubules are filled with dentinal fluid under constant pulpal pressure. The closer to the pulp, the higher the tubule density and the greater the diameter. Thus, near the dentinoenamel junction, the tubular area is about 1%, while near the pulp, the tubules occupy around 22% of the dentin area,[12] making it more challenging to achieve optimal adhesion to deeper dentin.

When dentin is abraded or cut during cavity preparation, a layer of organic and inorganic debris called the *dentin smear layer* is formed on its surface. The dentin smear layer commonly occludes the orifices of dentinal tubules, and the layers blocking the tubules are known as *smear plugs*. This obliteration of tubules by the smear layer reduces dentin permeability.[13] The type of interaction with the smear layer promoted by adhesive systems is one of the main differences between contemporary adhesive strategies. While the strategy advocating phosphoric acid conditioning of dentin (etch-and-rinse) completely removes the dentin smear layer, the self-etch strategy modifies it, incorporating it into the adhesive layer.

ADHESIVE SYSTEMS

Etch-and-rinse or total-etch adhesives

Since the 1950s, studies have demonstrated that prior enamel surface treatment with acids can enhance adhesion to this substrate.[4,5] Adhesive dentistry's success in enamel adhesion has long been attributed to conditioning enamel with 30% to 40% phosphoric acid for 15 to 30 seconds. After rinsing and drying the conditioned surface, an increase in surface energy and surface area occurs, facilitating the penetration of a low-viscosity adhesive resin (bonding resin) into the now-microretentive topography of the conditioned enamel. Polymerized adhesive forms a good micromechanical interlock with enamel, ensuring proper adhesion (retention and sealing). Adhesion to enamel is simple, effective, and long-lasting, and maintaining enamel margins during cavity preparation is a beneficial strategy for restoration longevity.[11,14]

In dentin, a more complex and variable substrate, achieving good adhesion is challenging due to substrate differences and the sensitivity to errors of etch-and-rinse adhesive systems. Initial generations of adhesive systems faced difficulties interacting with dentin (and the dentin smear layer), leading to the adoption of the total-etch technique wherein phosphoric acid is applied not only to enamel but to the whole dentinal surface. Phosphoric acid in dentin (applied for 15 seconds) removes the smear layer completely, demineralizes the dentinal surface by a few micrometers, opens dentinal tubule orifices (previously occluded by the smear layer), and exposes a network of collagen fibrils (organic content) previously "protected" by dentin mineral (hydroxyapatite). After rinsing, the moist and organic dentin surface requires preparation to receive the low-viscosity bonding resin, giving rise to the need for a primer—a mixture of more hydrophilic monomers in solutions with organic solvents. The primer helps reduce residual dentin surface moisture, thereby improving the wetting, infiltration, and interaction of the adhesive with the conditioned dentin. After application (preferably active) for an appropriate time (usually 20 seconds, per manufacturer instructions) and evaporation of the primer with an air stream (10 to 15 seconds), a low-viscosity bonding resin is applied, ideally filling the entire network of collagen fibrils exposed and primed by previous steps. Polymerization of this resin creates a dentin-adhesive interdiffusion zone called the *hybrid layer*, leading to adhesion through a micromechanical interlocking mechanism.

The previous paragraph outlines the basic dentin adhesion mechanism of a three-step etch-and-rinse adhesive system (1 = acid; 2 = primer; 3 = adhesive). These systems are commercially available with either three application steps, as previously described, or with two application steps (1 = acid; 2 = a solution containing both primer and adhesive functions in a single bottle).

Total-etch adhesive systems have both advantages (+) and limitations/difficulties (–) regarding their application technique and clinical performance,[15,16] including the following:

- (+) In enamel, prior etching with phosphoric acid followed by adhesion to a highly mineralized, clean, and dry substrate works well and shows excellent clinical results.
- (+) The micromechanical interlocking concept for adhesion works well in enamel and may have good results in dentin if a stable hybrid layer is formed.
- (–) In dentin, while the removal of the smear layer may be seen as favorable by some, phosphoric acid is aggressive and will demineralize the surface and leave collagen completely "unprotected" by hydroxyapatite, potentially favoring long-term degradation, especially through the activation of enzymes like metalloproteinases when collagen is exposed. Although studies suggest the application of solutions with metalloproteinase inhibitors (eg, chlorhexidine) after acid conditioning, there are still doubts about the long-term clinical relevance of this step.[17–19]
- (–) The application time of phosphoric acid is a critical step in dentin, as overetching can increase dentin demineralization depth, thus hindering proper primer and adhesive infiltration/interaction.
- (–) In dentin, after acid rinsing, it is recommended to keep the conditioned surface "slightly moist," which can be subjective and challenging to clinically standardize. However, this seems more crucial for systems using acetone as a solvent than those with alcohol or an alcohol/water mix. In the latter, even on slightly dry dentin, the issue of dentin moisture appears less relevant as long as the application time is respected and done actively.[20]
- (–) In dentin, after conditioning, rinsing, and controlling surface moisture, the primer function needs to occur adequately, making application and evaporation times of solvents and residual moisture paramount. Problems with the etched dentin preparation and/or moisture removal may result in inadequate adhesive infiltration and suboptimal polymerization, leading to a lower-quality hybrid layer that is more prone to degradation.[21,22]
- (–) Two-step etch-and-rinse simplified adhesive systems, despite a possibly faster and more user-friendly application protocol, may show worse long-term results than three-step systems.[23]
- (+) Three-step etch-and-rinse adhesive systems, despite a potentially more sensitive and complex protocol, generally exhibit good long-term clinical results. It is noteworthy that these adhesive systems usually have a separate application of the low-viscosity adhesive resin (adhesive or bond, step 3), which is more hydrophobic.[16,24]

Self-etch adhesive systems

Another strategy for adhesion is the self-etch approach. In this method, there is no mandatory preconditioning of dental substrates with phosphoric acid. However, this does not imply the absence of an acid function; rather, self-etch adhesive systems incorporate functional monomers that chemically interact with enamel and dentin, facilitating bonding (they invariably have an acidic pH to allow surface conditioning). Within this category, there are self-etch adhesive systems where functional monomers are in a solution with the primer function (step 1), followed by the application of an adhesive resin (step 2); these are referred to as *two-step self-etch systems*. There are also single-step self-etch systems, either available as a single bottle (the majority) or formed by the preoperative mixture of two solutions but applied in a single step on the tooth surface.

Self-etch systems do not have a rinsing phase, as the etching function (acidic pH) is incorporated either in the primer or in the primer/adhesive solution. Consequently, the dentin smear layer is not removed beforehand but is modified/incorporated into the adhesive interface.

The effect of self-etch systems on the smear layer and the entire dentin surface depends on the acidity of each system. Some strong (pH ≤ 1) or intermediate (pH ≅ 1.5) self-etch systems applied to dentin significantly demineralize it, dissolving smear plugs and resulting in a generally thicker hybrid layer (poor in hydroxyapatite) along with long resin tags extending into the tubules. Mild self-etch systems (pH ≅ 2.0) and ultramild ones (pH ≥ 2.5) tend not to completely dissolve the smear plug, keeping the tubules occluded. These systems modify the smear layer and etch with partial removal of minerals (exposing significantly fewer collagen fibrils), only from the dentin's more superficial layer, resulting in a thin hybrid layer characterized by larger amounts of remaining hydroxyapatite.[25]

In self-etch adhesive systems, there is some chemical interaction between functional monomers and dentin hydroxyapatite. This interaction varies depending on the type of monomer used in each system. Some monomers undergo a chemically unstable and less durable reaction, while others interact with the dentin mineral in a chemically stable and long-lasting manner. Among commercially available functional monomers, 10-MDP (10-methacryloyloxydecyl dihydrogen phosphate) stands out, demonstrating ionic reaction of its phosphate group with hydroxyapatite's calcium, creating a chemical bond between dentin and the adhesive through nanolayers.[26–28] The evolution of products and knowledge on this subject suggests that the best laboratory and clinical results with self-etch systems on dentin appear to occur with mild/ultramild pH systems that generate thin hybrid layers that are rich in hydroxyapatite, providing mineral availability for the reaction of functional monomers like 10-MDP.

However, the reduction in acidity (higher pH), which seems beneficial for a self-etch system to adhere to dentin, does not seem to be positive for enamel adhesion. Enamel, which is more mineralized and has minimal organic content, does not achieve an ideal etch by way of milder self-etch systems, just as its hydroxyapatite crystalline structure does not favor a chemical reaction with functional monomers as significantly as dentin does. Therefore, in enamel, studies suggest that there are benefits to prior etching with phosphoric acid, even when using self-etch systems; this technique is known as *selective enamel etching*.[29–32]

There are positive aspects (**+**) and limitations/difficulties (**–**) regarding the technique and performance of self-etch adhesive systems,[15,16] including the following:

- (**+**) An absence of phosphoric acid conditioning in dentin avoids possible overconditioning and moisture control problems and reduces dentin surface demineralization and the consequent exposure of collagen fibrils completely devoid of hydroxyapatite, thereby promoting less matrix metalloproteinase activation.
- (**+**) Mild and ultramild self-etch systems form a thin hybrid layer rich in hydroxyapatite, with minimal exposed collagen, promoting sufficient micromechanical interlocking and allowing a stable chemical bond between dentin mineral content and adhesive functional monomers (depending on the monomer in each adhesive system).
- (**–**) One-step self-etch systems that combine acid, primer, and adhesive functions in a single solution, especially those with a stronger pH, usually form more hydrophilic polymers that are more prone to degradation. Some strong-pH self-etch adhesive systems (now rare in the market) have shown unsatisfactory clinical results.
- (**–**) The low acidity of mild and ultramild self-etch systems may reduce enamel adhesion quality, leading to greater issues with retention and marginal staining. Therefore, the selective enamel conditioning technique, or at least increased application time and active friction of the self-etch system on enamel, are strongly recommended.

- (+) Mild or ultramild self-etch systems, especially those containing stable functional monomers like 10-MDP and that have a second application step with a more hydrophobic adhesive resin, tend to show very satisfactory clinical results that are comparable to those of three-step total-etch adhesives.[33]

Universal adhesive systems

Universal (or multimode) adhesives can be applied according to the professional's preferred strategy, such as with total phosphoric acid etching (etch-and-rinse), solely in a self-etch manner, or with prior phosphoric acid only on enamel (selective enamel etching). They are usually presented in a single bottle, in a solution that encompasses the functions of acid, primer, and adhesive. Evolving from one-step self-etch systems, they generally have a mild or ultramild pH and phosphate monomers, with 10-MDP being prevalent in most commercial brands.[34]

As previously mentioned, the simplification/combination of various functions into a single adhesive solution tends to pose challenges for achieving an excellent polymer quality. Despite the mild pH that benefits dentin adhesion, as well as the possibility of chemical adhesion and greater hydrophobicity of 10-MDP compared to other monomers, universal adhesives face limitations due to the common presence of hydrophilic monomers, such as HEMA (hydroxyethylmethacrylate), and solvents, including water. Nevertheless, it is intriguing to observe the positive clinical results of universal adhesive systems, which, despite being relatively new to the market, show positive data in follow-ups of up to 5 years.[35]

Although universal adhesive systems indicate their possible use in different adhesive strategies, it is essential to recall that, in enamel, phosphoric acid conditioning brings genuine benefits, thus improving adhesion quality. The non-use of acid in dentin facilitates the technique, exposes a lesser amount of collagen, and preserves more mineral in the hybrid layer, allowing greater interaction with phosphate monomers and consequent chemical adhesion. Therefore, it is believed that the best strategy for these adhesives is selective enamel etching.[29,30]

There are positive aspects (+) and limitations/difficulties (–) regarding the technique and performance of universal adhesive systems, including the following:

- (+) Although selective enamel etching is ideally indicated, the ability to choose the adhesive strategy according to the case is a positive factor.
- (+) A majority of the industry releases in the last decade fall into this category, emphasizing technique simplicity and fewer steps to minimize application errors. Research developments and the evolution of these new materials are expected to translate into quality long-term clinical results, although this remains to be seen.
- (+) Clinical study results (short- and medium-term) to date are mostly positive, although they present product dependency.
- (–) The simplification into a single bottle and the presence of hydrophilic monomers (like HEMA) and solvents (including water) in their composition may hinder the formation of a polymer resistant to hydrolytic degradation in the long term.
- (–) The formation of a very thin adhesive film, coupled with the absence of a separately applied hydrophobic layer, may be a disadvantage. However, despite some in vitro studies suggesting the application of a layer of low-viscosity adhesive resin after the universal adhesive,[36,37] the benefit of this practice has not been clinically confirmed.[38]

CLINICAL TIPS FOR THE APPLICATION OF ADHESIVE SYSTEMS

Every adhesive procedure requires a clean and dry operative field with absolute control over contamination and moisture. Therefore, proper isolation of the region where adhesion will be performed is an indispensable condition for the technique.

Etch-and-rinse system (3 steps)

1. Begin the etching step with phosphoric acid at the enamel margins, then extend it to the dentin (acids with a fine-tipped syringe and a viscosity that aids in application control are helpful). Do not let the acid contact dentin for more than 15 seconds. Rinse copiously. Remove excess moisture without desiccating the dentin, either with water-absorbing materials or gentle air streams. If the primer is alcohol/water-based (most products), keeping the dentin “slightly moist” does not seem as relevant.
2. Apply the primer over the entire dentin surface. There is no need for priming enamel, but in cavities with both enamel and dentin, control is impossible, and application on enamel does not cause any harm. The primer should be actively applied (vigorously massaging the dentin with the microbrush) for at least 15 to 20 seconds. The longer, the better. It is essential to volatilize solvents and residual moisture with gentle air streams for at least 10 seconds.
3. Apply a layer of low-viscosity adhesive resin (bond) and spread it over the entire preparation with a new microbrush. Remove excess adhesive and make its layer uniform, either through suction with a thin cannula or, more commonly, using a dry microbrush. Light cure for 20 seconds with a properly positioned, high-quality curing light.

*Some steps may vary from manufacturer to manufacturer. Consult your product’s instructions for use.

An example case performed using this system is shown in Figs 1-1 to 1-7.

FIG 1-1 Case 1: Etch-and-rinse adhesive. Initial view of a mandibular first molar showing an unsatisfactory amalgam restoration.

FIG 1-2 Rubber dam isolation is placed prior to the removal of the amalgam restoration.

FIG 1-3 Cavity appearance after restoration removal. Note the dark substrate, indicative of sclerotic dentin on the pulpal wall.

FIG 1-4 Total etching is performed using 35% phosphoric acid (Ultra-Etch, Ultradent). It is important to begin with etching the enamel, as this substrate requires a different etching time (15 to 30 seconds) than dentin (15 seconds). After etching, the acid must be thoroughly rinsed with an air-water spray for at least 15 seconds to remove all acid residues and gel components.

FIG 1-5 Application of the etch-and-rinse dental adhesive (Peak Universal Bond, Ultradent) using a microapplicator (ZerofloX, Medmix).

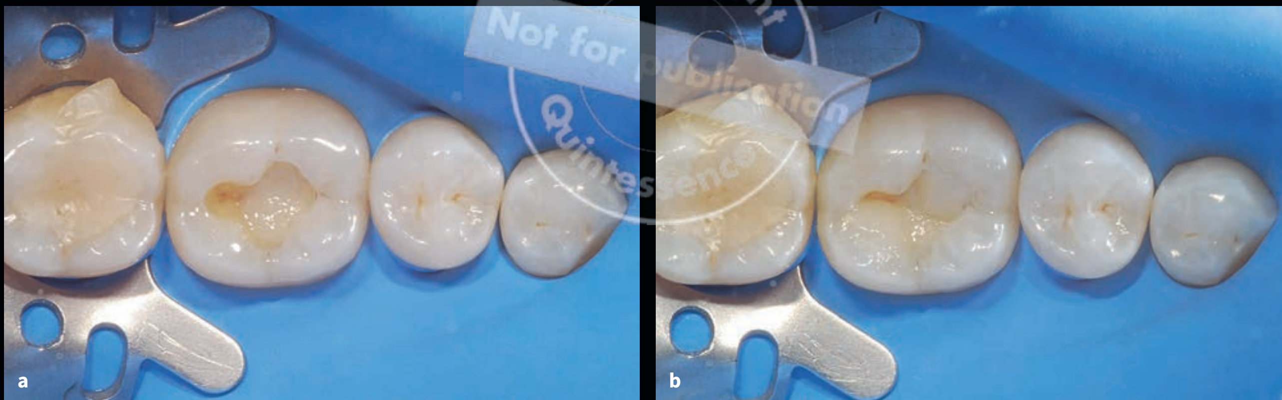

FIG 1-6 Incremental placement of the composite material. *(a)* The first increment, an A2 dentin shade (Transcend, Ultradent), was applied to mask the dark substrate and reduce cavity depth, standardizing the pulpal wall. *(b)* Two increments of a monochromatic composite (Transcend Universal Body, Ultradent) were placed on opposite sides and light cured. *(c)* Final increments were added to complete the restoration.

▼ **FIG 1-7** Final appearance of the restoration after verifying occlusal contacts. Note the natural color and anatomical contour achieved with the composite restoration. (Clinical case performed and documented by Dr Adriano F. Lima.)

Etch-and-rinse system (2 steps)

1. Etch enamel and dentin with phosphoric acid in the same way as done for the three-step system. Rinse well and remove excess moisture without desiccating the dentin. For water/alcohol-based solvents, keeping dentin "moist" does not seem as important.
2. Actively apply the primer/adhesive solution over the entire surface, rubbing for about 15 seconds. Remove excess solution with a suction cannula or dry microbrush, and volatilize solvents and residual moisture with a gentle air stream for 10 to 15 seconds. Repeat the process of applying the adhesive solution, rubbing for 15 seconds, removing excess, and applying an air stream for 10 to 15 seconds. Light cure for 20 seconds with a well-positioned curing unit.

*Begin your restoration promptly (composite resin layers) or apply a more hydrophobic layer (such as a flowable resin) and light cure it. Simplified adhesives seem to form a thin, semipermeable membrane and should be promptly sealed with a hydrophobic agent.

**Some steps may vary from manufacturer to manufacturer. Consult your product's instructions for use.

Self-etch system (2 steps)

(Optional, but highly recommended) Etch only the enamel with phosphoric acid for 15 seconds, rinse well, and dry with an air stream.

1. Apply the acidic primer actively (by rubbing) on the enamel and dentin for at least 20 seconds. Remove rough excess with a thin suction cannula or a dry microbrush, and use a gentle air jet for 10 to 15 seconds to volatilize the solvents.
2. Apply a layer of low-viscosity adhesive resin (bond); remove excess material and leave a uniform layer, using a suction cannula or dry microbrush. Light cure for at least 20 seconds in an ideal position.

*Some steps may vary from manufacturer to manufacturer. Consult your product's instructions for use.

An example case performed using this system is shown in Figs 1-8 to 1-15.

FIG 1-8 Case 2: Self-etch adhesive. Initial view of an unsatisfactory restoration on the occlusal and buccal surfaces of a mandibular first molar.

FIG 1-9 Rubber dam isolation is placed before the removal of the amalgam restoration.

FIG 1-10 Cavity appearance after restoration removal.

FIG 1-11 Selective acid etching of the enamel surface was performed using 35% phosphoric acid (K-Etchant, Kuraray Noritake) for 15 seconds. It is crucial to use an acid gel with appropriate thixotropic properties to prevent flow onto the dentin substrate, as unintended demineralization of the dentin can compromise the chemical adhesion to this substrate.

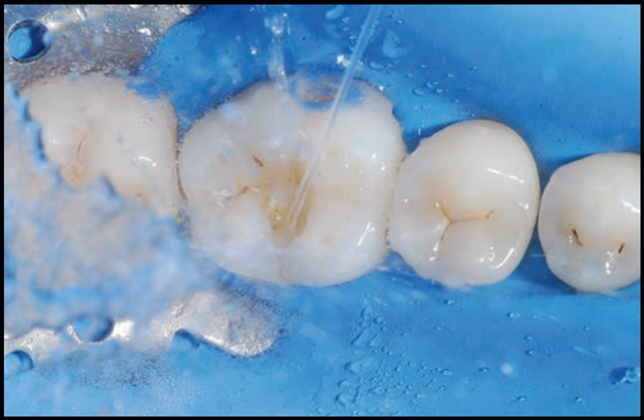

FIG 1-12 The acid-etched surface is rinsed with an air-water spray for at least 15 seconds to ensure complete removal of acid residues and gel components.

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