

# BONDING

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Dentalelle Tutoring

# BASICS

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# Tooth Bonding Basics

- Enamel is the most highly mineralized body tissue. (98% mineral content vs. 70% for bone.)
- If an acidic solution is placed on enamel it will dissolve away some of this mineral content AND takes away the smear layer for effective bonding.
- And after this treatment, at a microscopic level its smooth surface will be transformed into one that's jagged and rough IF etch was done properly
- **How does it work?**
  - Dental bonding science exploits the microscopic surface roughness of etched tooth enamel. The tooth's etched surface is coated with a liquid plastic referred to as "bonding agent"
  - **Since it's a liquid, it's able to seep in between the nooks and crannies of the tooth's etched surface.** Then, once it's cured (hardened), it becomes locked (bonded) onto the tooth's surface.

# Mechanical and Chemical Bond

- The attachment that dental bonding creates with a tooth is a **simple mechanical one**. It's due to an interlocking of the cured bonding agent within the nooks and crannies of the etched enamel surface.
- Once the etch, and bonding is in place, composite is placed after that (when referring to resin) and this is when it locks into place firmly. This is a **chemical bonding**.

# Resin/Composite

- At its core, dental composite is just a plastic compound. Because the physical properties of this core plastic leave a lot to be desired, fillers and modifiers are added. They help to enhance characteristics such as strength, wear resistance, consistency and color. After all have been added in, the end product is a white, putty-like material.
- (The types of fillers usually used are finely ground particles of quartz, glass, zirconium, silica, barium, and strontium.)
- The specific types and amounts of modifiers that are added depend on the type of applications the composite is intended for. For example, if it will be used to create white fillings for back teeth, then fillers that enhance strength and wear resistance will predominate.
- In comparison, if the composite will be used in applications with front teeth, then fillers that enhance the composite's color, translucency and polishing characteristics will be emphasized.

# Light cure

- Modern dental composites are formulated with a catalyst that triggers its hardening process. **What's key is that this catalyst is only activated when it's exposed to a special color of light.**
- The curing light goes on the composite and it will harden within 20 to 40 seconds.
- Dental "curing lights" are hand-held units that produce visible spectrum output (light) that lies within a specific wavelength range. Usually this is blue-colored light that has a wavelength between 420 and 450 nm.

# Smear Layer

- Cavity preparation alters the uppermost layer of tooth tissue, covering the tooth surface with a 1.0  $\mu\text{m}$  to 2.0  $\mu\text{m}$  layer of **cutting debris**. The orifices of the dentin tubules are obstructed by smear plugs contiguous with the smear layer consisting of shattered and crushed hydroxyapatite, as well as fragmented and denatured collagen. In clinical conditions, these may also be contaminated by bacteria and saliva. In order to overcome this smear layer obstacle, a certain degree of etching is required.
- There are **basically two options** (ie, removal of the smear layer prior to bonding following an etch-and-rinse procedure, or the use of adhesives that can penetrate beyond the smear layer while incorporating it following a self-etch approach)
- For both approaches, micromechanical interlocking is the basic mechanism of adhesion to enamel and dentin

# Etch and Rinse

- All categories of adhesives exhibit the common adhesion mechanism of hybridization. A hybrid layer results from the process of micromechanical interlocking ensuing a demineralization, infiltration, and polymer-setting process and was first described by Nakabayashi et al.<sup>6</sup>
- Etch-and-rinse adhesives can readily be recognized by an initial etching or conditioning step, followed by a rinsing phase. They are often called "total-etch" adhesives.
- The etching step removes the smear layer/plugs, produces etch pits at enamel, and demineralizes dentin in order to achieve a micro retentive surface. Originally, three-step etch-and-rinse systems typically consisted of three separate application steps (ie, conditioning, priming, and adhesive-resin application).
- In search of simplification, a two-step etch-and-rinse approach was developed to combine the priming and bonding steps into one; this approach is frequently referred to as "one-bottle adhesives," which misleadingly suggests a single-application step. Both three- and two-step etch-and-rinse adhesives pursue a similar adhesion mechanism.



# Continued

- Currently, bonding to enamel is still best accomplished through the use of the etch-and-rinse approach. Etching with 35% phosphoric acid removes the enamel top layer for a few micrometers and selectively dissolves hydroxyapatite crystals within prismatic and interprismatic enamel. This increases microscopic roughness, surface area, and energy.
- This bond to enamel not only effectively seals the restoration margin, but also protects the more vulnerable bond to dentin against degradation.

# Continued

- At dentin, phosphoric acid removes the smear layer while concurrently demineralizing dentin over a depth of 3.0  $\mu\text{m}$  to 5.0  $\mu\text{m}$ , thereby exposing a scaffold of collagen fibrils nearly depleted of hydroxyapatite.<sup>8,9</sup>
- The exposed collagen fibrils function as a micro retentive network for micromechanical interlocking of resin monomers that diffuse into it and in situ polymerize, eventually forming a hybrid layer. Re-expansion of the collagen mesh that has collapsed upon post conditioning air drying is especially crucial to improve the bond strength of the adhesive.
- **Etch and rinse adhesives can achieve high-quality adhesion to both enamel and dentin**, and that three-step etch-and-rinse adhesives commonly exhibit superior performance over their two-step counterparts.
- **The primer solvent within etch-and-rinse adhesives is a major factor affecting their handling and performance.** Water/ethanol-based adhesives are regarded as the most forgiving in terms of application errors, while acetone-based adhesives require the more challenging "wet-bonding" technique.
- New etch-and-rinse adhesive technology has consisted of the use of ter-butanol as solvent into a recent two-step etch-and-rinse adhesive.

# Self-Etch Adhesives

- Self-etch adhesives were first developed by raising the amount of acidic monomers in HEMA/water-based adhesives. **They do not require a separate etch-and-rinse phase**, as they contain acidic monomers that simultaneously condition and prime enamel and dentin.
- As a result, the dissolved smear layer and demineralization products are not rinsed away, but incorporated in the adhesive resin.
- Self-etch adhesives can be subdivided by the number of application steps. **Mild self-etch** adhesives demineralize dentin shallowly, forming a submicron hybrid layer, while leaving hydroxyapatite crystals around the collagen fibrils. **Strong self-etch adhesives** produce resin tags, along with a 3.0  $\mu\text{m}$  to 5.0  $\mu\text{m}$  thick hybrid layer resembling the interfacial interaction of an etch-and-rinse adhesive; all hydroxyapatite is dissolved within the hybrid layer. Intermediate self-etch adhesives exhibit morphological features that lie between the mild and strong self-etch adhesives

# Continued

- In spite of the small hybrid layer and the absence of resin tags (ie, minimal micromechanical retention), some mild self-etch adhesives do reach a satisfactory bond strength.
- **When bonding to enamel, the strong self-etch adhesives generally perform better than the higher-pH self-etch adhesives.** Nevertheless, with some mild self-etch adhesives, a high and stable bond strength is achieved; this most likely must be attributed to the good chemical interaction potential of the functional monomer 10-MDP. The interaction with enamel is quite shallow with the sole formation of micro tags.
- While bonding to enamel may remain a problem, especially with mild self-etch adhesives, bonding to dentin has reached results comparable to those obtained by the gold standard three-step etch-and-rinse adhesives.
- Recent studies have also reported good clinical results for some self-etch adhesives

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- **Self-etch adhesives have had numerous advantages attributed to them.**
  - It has been suggested that they improve the efficiency in clinical procedures by omitting the obligatory rinsing phase in etch-and-rinse adhesives, thereby reducing chairside time.
- Conditioning, rinsing, and drying steps, which may be critical but difficult to standardize in clinical conditions, are eliminated in self-etch adhesives. Technique sensitivity associated with bonding to dehydrated demineralized dentin is eliminated, as rinsing and drying phases are no longer needed.
- **Collapse of the collagen network is prevented**, since monomers infiltrate concomitantly as they demineralize. Theoretically, incomplete resin infiltration is prevented in this manner as well. As the smear layer and smear plugs are not removed prior to the actual bonding procedure, rewetting of dentin by dentinal fluid from the dentin tubules is prevented, and a reduction of postoperative sensitivity has been reported.

# Continued

- The composition of self-etch adhesives is quite unique as they contain high concentrations of water and acidic monomers. Providing an ionization medium for the functional monomers, water is an indispensable ingredient of current self-etch systems.
- Two-step self-etch adhesives consist of a hydrophilic aqueous primer solution and a separate hydrophobic adhesive resin. Similar to the combined primer/adhesive resin solution of two-step etch-and-rinse adhesives, **one-step self-etch adhesives are complex mixtures of hydrophilic and hydrophobic components.**
- In particular, the high concentrations of water have raised questions about potentially harmful effects on polymerization, given that complete water removal is unrealistic.
- This also applies for the high concentrations of solvent, which may cause incomplete resin polymerization in instances of incomplete evaporation.

# DENTIN

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# History of Bonding Agents

- The first attempt to develop an adhesive system for bonding to dentin was made by Hagger, a Swiss chemist working for the Amalgamated Dental Company in London and Zurich in 1951. The first commercial product (Sevriton Cavity Seal), based on glycerophosphoric acid dimethacrylate, was used to bond an autocuring acrylic resin, Sevriton, to dentin. Work at the Eastman Dental Hospital, London, showed that glycerophosphoric acid dimethacrylate increased adhesion to dentin by penetrating the surface and forming an intermediate layer, now called the *hybrid zone*. This was detected because the dentin exhibited an intense affinity of hematoxylin staining, and the zone of altered dentin had affinities similar to those of calcified dentin in an exaggerated form.
- It is interesting to note that, despite the use of a methyl methacrylate resin as the restorative material, the pulpal reaction to Sevriton plus cavity seal was similar in intensity to that recorded for other autocured resins. Although Sevriton was capable of causing an acute inflammatory reaction when placed in moderately deep, unlined cavities, the usual outcome of this reaction was resolution.
- Materials introduced in the early 1980s, such as Gluma, Tenure, and Scotch Bond II, represented the first generation of dentin bonding systems that created sufficiently strong bonds to dentin.
- Buonocore et al reported a dentin bonding agent using a cavity primer containing glycerphosphoric acid dimethacrylate with bonding being achieved primarily by the interaction of the phosphate group with the calcium ions on the dentin surface. Designed for restoring cervical lesions without mechanical retention, the process consisted of conditioning the dentinal surface with citric acid. The procedure removed the smear layer and opened the dentinal tubules, permitting the influx of the resin restorative material to a depth of 50 - 100 microns. The composite containing a chelating agent had the potential to bond to the dentin's calcium component.
- However, the bond strengths which were achieved were found to decrease from 58 kg/cm<sup>2</sup> (5.7 MPa) to 28 kg/cm<sup>2</sup> (2.7 MPa) after 5 months of water immersion. This was thought to be due to the linkage between phosphate and monomer being easily hydrolyzed, with a consequent reduction in bond strengths.



# Continued History

- The principal barrier to effective adhesion to dental tissue is water. Water will compete with a potential adhesive for the surface of a substrate and can also hydrolyze adhesive bonds. Modern dentinal bonding agents have evolved from the original concept of increasing dentinal permeability and wettability and promoting bonding to the smear layer, to the partial removal of the smear layer, and finally to the use of stronger etchants to modify or remove the smear layer and obtain some form of micromechanical retention.
- The next generation of dentin bonding agents differed from their predecessors by the use of a solution, or series of solutions, which were applied to the dentin surface to modify it prior to application of the resin. In many systems, these primers were applied to the surface and not washed off, while some also required the use of conditioners which were applied and subsequently washed off. The additional stages required for priming and conditioning made the chairside use of these materials more complicated and time-consuming than previous materials, but the bond strengths to dentin were generally higher and more reliable in the oral environment.
- **Because enamel is an ion exchanger and dentin is a living material subject to change, one is trying to bond to shifting sand rather than to solid rock.** Under such conditions, the adhesive bond must have a dynamic character too. It will be broken as the substrate changes and must be capable of being re-formed. Once broken, covalent chemical bonds cannot be re-formed. Dentinal adhesives may fail for this very reason.

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- Many later generation dentin bonding systems use mechanical means of adhesion rather than the unreliable chemical bonding seen in previous materials. Those systems which utilize the hybrid or resin-reinforced concept have been considered to perform better than those which attempt to achieve chemical bonding.
- **The latest or fourth generation of dentin bonding agents differentiate from the previous systems in three ways:**
  - minimal technique sensitivity, similar bond strengths to enamel and dentin, and no reduction in bond strength when applied to a moist surface.
- Furthermore, because the adhesion to dentin is nearly the same as to enamel, the problems of marginal adaptation and micro leakage have been reduced.

# Continued

- Recently introduced materials include Pertac Universal Bond, Scotchbond MP and Gluma 2000, each of which is characterized by its user-friendliness in comparison with the previous systems. The application speed of these materials may have reached the ultimate from the viewpoint of operational feasibility. The total application time with Pertac Universal Bond is 100 seconds compared to 130 seconds with the previous materials; the primer and Solution 2 of the Gluma 2000 systems require application time of 30 seconds each, and the etchant solution and primer of Scotchbond MP require application of 15 and 5 seconds respectively and the resin requires curing for 10 seconds.
- Experimental work using the Scotchbond MP system has shown that, when used with the 10% maleic acid etchant provided by the manufacturers, bond strengths to dentin and enamel of 23.0 MPa and 25.7 MPa, respectively were achieved. These strengths were found to increase to 26.2 MPa (to dentin) and 26.9 MPa (to enamel) with the substitution of a phosphoric acid etchant.
- **The fourth generation dentin bonding agents, such as All-Bond, Amalgambond, Mirage Bond, Tenure, show satisfactory or even enhanced adhesion to visibly moist dentin.** This does not mean that the dentist should allow the cavities to be contaminated with saliva during restoration placement as it decreases bond strength, but the development of a system that functions in a slightly moist environment without reduction in its properties has a definite clinical advantage.
- There is a good correlation between dentin/resin bond strength and microleakage, and since early generation dentin bonding systems did not produce sufficiently high bond strengths they were plagued with the problem of microleakage. In this respect, the microleakage of six dentin bonding systems (Optibond, Clearfil Liner Bond, Prisma Universal Bond, Scotchbond MP, Gluma 2000 and Imperva Bond) has been assessed by Fortin & Swift, whose results indicated significantly less microleakage when using Optibond.

# Recently introduced dentin bonding systems:

- Gluma 2000
- Conditioning solution: 4.3% organic acids, 2.6% aluminium salts, in aqueous solution
- Bonding solution: 28.9% mono and polyfunctional metacrylic acid
- Pertac Bond
- Bonding resin: Methacrylated carboxylic acid; hydrophilic and
- hydrophobic methacrylates; camphorquinone and activator
- Scotchbond Multi-Purpose
- Etchant: 10% maleic acid
- Primer: Aqueous solution of HEMA; polyalkenoic acid copolymer.
- Adhesive resin: Bis-GMA; HEMA; proprietary photoinitiator
  
- *Source: Burke FJ, McCaughey AD. The four generations of denting bonding. A J Dent 1995; 8: 88-92.*

# Modern Bonding

- Modern dentinal bonding agents used with acidetching procedures produce high bond strength values, *but these figures should not be confused with long-term resistance to microleakage, which has been shown to occur even in the absence of gaps under a resin composite placed in Class V cavities with an adhesive resin system.*
- The dentinal surface and the smear layer after tooth preparation show many variations, with the result that short-term in vitro studies of the strength of dentinal bonds cannot always give the clinician an accurate picture of the future clinical situation. Paul and Scharer believed that there has been a discrepancy between the results of laboratory testing and the in vivo performance of the dentinal bonding systems; they attributed the difference to dentinal fluid, that under pressure, leaked out of numerous cut tubules and changed the conditions of the chemical reaction of the adhesive resin to the dentin
- The interlocking of the bonding agent with the collagen network of the intertubular dentin and not the tag formation into the tubuli was considered to be the main substrate that yields high bond strengths to dentin.
- It is now generally agreed that where the area of intertubular dentin is maximal, as in outer dentin, better bond strength figures can be obtained.

# Bonding Agents

- Considerable support is emerging, both in the clinical and research fields, for the use of mild acid etchants, such as maleic acid, to demineralize the intertubular dentin, allowing hydrophilic primers to infiltrate the collagen network and form a thin hybrid layer or zone of resin-impregnated dentin.
- **The only question that still remains unanswered is how long this seal will last when placed under stress and subjected to long-term exposure to oral fluids. A**
- The resistance of the restoration to long-term microleakage should be the main consideration when techniques and materials are selected for adhesive bonding.

# Resin

- The larger the bulk of the resin composite restoration, the greater the effect of stresses produced by polymerization shrinkage. In the large posterior restoration, bonding to cervical dentin involves greater risks of microleakage because inner dentin has less intertubular dentin and because there is an increase in dynamic occlusal stresses.
- At present, the use of composites placed on dentinal margins is better confined to small cavities and low-stress-bearing areas.
- However, the use of resin bonding agents to seal dentin under porcelain, gold, or amalgam restorations is enjoying greater success, although as yet much of the evidence for this is anecdotal.

# Glass Ionomer Cement

- The use of glass-ionomer cement as a base or dentin substitute for attaching composite restorations to tooth structure was first described by McLean and Ilson in 1977.
- The efficacy of cavity sealing by glass-ionomer bases has had a long history of success and has been confirmed in numerous clinical studies. In addition, **because the glass ionomer cements liberate fluoride, they possess some cariostatic properties.**
- Provided that these cements are placed on a clean dentinal surface, their long-term resistance to microleakage has been proven over periods of more than 15 years.
- A further advantage is that, when these cements are used as dentin substitutes in the so-called sandwich technique, they reduce the bulk of overlying composite and subsequent polymerization shrinkage.
- In the case of the Class III restoration, a glass-ionomer base can often improve esthetics because the cement's transmission of light is close to that of dentin, preventing the halo effect sometimes observed with the more translucent microfilled composites.



# Sandwich Technique

- In the shallow cavity, loss of seal in the sandwich technique is often related to the strength and thickness of the base used, **and thin linings of less than 1.0 mm are not always satisfactory.**
- Essentially, glass-ionomer cement should be used as a dentinal substitute to protect the dentin from any acid penetration during insertion of the composite. The cement itself should be protected with a glass-ionomer bonding agent, as previously described, prior to acid etch. **In the shallow cavity, the clinician should continue to use direct dentinal bonding.**

# Resin Modified Glass Ionomer Cements

- Their advantages are ease of placement, setting on command, and early resistance to moisture contamination. It is not possible to photocure a regular glass-ionomer cement, and it is necessary to modify the polyacid by grafting methacrylate groups onto the poly (acrylic acid) chain. Because the modified poly (acrylic acid) is less soluble in water than its parent, hydroxyethyl methacrylate (HEMA) is added as a cosolvent.
- When this hydrophilic species is included, the set cement will act, to some extent, like a hydrogel, swelling in water and becoming weaker. In general, the greater the amount of HEMA incorporated, the greater the swelling and reduction in strength.
- A proposed classification for these new cements has attempted to differentiate between the true glass ionomer cement and the newer hybrid varieties:
  1. The unqualified term *glass-ionomer cement* should be reserved exclusively for a material consisting of an acid-decomposable glass and a water-soluble acid that sets by a neutralization reaction.
  2. Materials that retain a significant acid-base reaction as part of their overall curing process, ie, they will cure in the dark, are classified as *resin-modified glass-ionomer materials*.
  3. Materials that contain either or both of the essential components of a glass-ionomer cement but at levels insufficient to promote the acid-base curing reaction in the dark should be referred to as *polyacidmodified resin composites*.

# Resin modified and Glass Ionomer Cements

- The clinical implications for the swelling in water of the resin-modified materials have yet to be established, and their use as a base or core for inlays or crowns could result in a misfit if the cement absorbs water and swells after the impression is taken.
- **In the case of bases under resin composite or amalgam alloy restorations, the amount of swelling is unlikely to affect the stability of the restoration,** provided that the resin-modified glass-ionomer cement that is selected has a significant glass-ionomer acid-base reaction and will still cure rapidly in the dark.
- Knight has described a method of overcoming the stresses placed on glass-ionomer bases by the polymerization shrinkage of composites: the resin-modified glass-ionomer base and resin composite are cured simultaneously.
- He postulated that the resin composite cures before the resin-modified glass-ionomer material and that shrinkage stresses could be absorbed by the more plastic glass-ionomer base. This is an interesting approach and deserves further study, particularly when conventional glass-ionomer bases are used.

# Continued

- If the resin-modified materials are used as a total restorative **in Class III and Class V cavities**, the implications of the water uptake must be taken into account, with regard to not only marginal adaptation but also color stability. The formation of hydrogels in the resin-modified glass-ionomer cements and subsequent swelling in water **may result in discoloration over time**, and the results of long-term clinical trials are still awaited. It is for this reason that research aimed at producing faster-setting and stronger regular glass ionomer cements that set by an acid-base reaction should be continued, together with attempts to introduce alternatives to HEMA in the resin-modified materials.
- The polyacid-modified composite materials also require longer-term clinical trials, because **although they are stronger** than either glass-ionomer or resin modified materials, they are still *significantly weaker than regular hybrid or microfilled composites*. They also do not cure in the dark, which indicates the absence of any significant degree of acid-base reaction.
- A clinical question still remains as to their performance compared with that of the hybrid or small-particle composites, particularly in posterior restorations. In addition, there seems to be little evidence that these materials can adhere to dentin by chemical bonding, as occurs with the glass-ionomer acid-base reaction cements, and they still require an acid-etching procedure, as used for conventional dentinal bonding agents, to obtain high bonding strengths.

# Class V

- **The retention rate of glass-ionomer cements in the erosion/abrasion lesion solely involving dentin is generally better than that of dentin-bonded composite restorations.** For this reason, other questions of choice will depend on esthetic demands and the maintenance of polished surfaces. Modern composite restorations have great esthetic appeal, but both the standard and resin-modified glass-ionomer materials have been considerably improved with regard to translucency and color.
- Although the composite restoration may exhibit superior color in the early years, the standard glass-ionomer cements can maintain greater color stability because of their chemical stability. **However, poor finishing techniques can produce rough surfaces that stain,** and preservation of the original gel surface should be the clinician's prime objective, as described by McLean and Wilson in 1977.
- Provided that this goal is achieved, glass ionomer cements are very durable in cervical restorations and compete with the composites, particularly where bonding to cervical dentin is required. Sclerosed dentin remains the greatest obstacle to obtaining good bonding with dentinal bonding agents, and failure at the cervical margin as a result of microleakage is not always easily detected.
- **Class V cavities may also be restored with glass ionomer cements, but esthetic considerations take priority when more extensive facial areas are involved,** and the small-particle or microfilled composites are superior. The sandwich technique is only practical in the deeper cavity and should be the first choice where caries control is a priority for the older patient. Shallow cavities are better restored with direct dentin bonded composites, but again the area of cervical dentin involved will influence the longevity of the restoration. An alternative is to place a conventional glass-ionomer restoration, which can later be cut back and overlaid with an acid-etched composite

# Class II

- Direct bonding of composites to dentin in the posterior restoration is generally regarded as the most challenging operation by the clinician. He or she has to contend not only with moisture control but also with dentinal surfaces that are not as receptive to hybridization. In addition, as described previously, the bulk of the restoration will determine the amount of polymerization shrinkage and subsequent distribution of stress.
- **Unless the entire restoration can be bonded to peripheral enamel, a strong case can be made for using a glass-ionomer base (conventional, cermet-based, or resin-modified) to act as a biologic seal and offer protection to the surrounding tooth structure through the release of fluoride.** The glass-ionomer base also avoids the risk of damage by acid etching in the deeper cavity, postoperative sensitivity is reduced, and bulk shrinkage of the composite restoration is lessened.
- **The sandwich technique has been misapplied to this type of restoration.** Attempts to use glass-ionomer cement as a base, so that the cement is extended to the surface at the cervical margin, may result in dissolution of the cement. Glass-ionomer cements should only be used as internal bases. However, in a recent 3-year clinical study comparing direct composite inlays with conventional restorations, Wassell et al observed that there was no evidence of dissolution of a cermet base, even when it extended to the cervical margin, in either type of restoration, and no secondary caries was diagnosed. It is possible that the fluoride release and better abrasion resistance of this material may have contributed to this result.
- The imperfections of the large mesio-occlusodistal composite restoration are well known, and, despite current attempts to ban amalgam alloy restorations, the public must be made aware of these deficiencies. Composites can provide good service in small Class I and Class II preparations with minimal direct stress, because occlusal contact is generally confined to the tooth enamel and the restoration is to some extent protected. However, despite improvements in the chemistry and particle-size distribution of the fillers, the hydrolytic stability of the filler-matrix interface still remains questionable and may result in loss of material in functional occlusion, where occlusal stability is so vital. Wear in the contact area also remains a problem.

# Dentin Bonding

- Although adhesion to enamel has become routine, dentinal adhesion is more difficult because of the complex structure and variable composition of dentin. It is generally agreed that the major difference between the success of enamel bonding and that of dentinal bonding lies in the substrate surface. Enamel is composed largely of hydroxyapatite and has a very low water content.
  - By contrast, dentin varies considerably and may be very dense, with only 1% of the surface at the dentinoenamel junction consisting of tubules, or very porous at the pulpal floor, where as much as 22% of the total surface area may consist of dentinal tubules.
  - Dentin is permeated by fluids transported from the pulp, and there is both loosely and tightly bound water even in enamel.
  - Dentinal bonding is also complicated by the formation of a smear layer when the dentin is cut or ground. Bacteria can become entrapped in this smear layer and multiply beneath restorations.
- \*\*Until recently, clinicians did not properly understand the presence and nature of the smear layer.**

# Ideal Dentin Bonding Agent

- 1. Provide a high bond strength to dentin, which should be present immediately after placement and which should be permanent
- 2. Provide a bond strength to dentin similar to that to enamel
- 3. Show good biocompatibility to dental tissues, including the pulp
- 4. Minimize microleakage at the margins of restorations
- 5. Prevent recurrent caries and marginal staining
- 6. Be easy to use and minimally-technique sensitive
- 7. Possess a good shelf life
- 8. Be compatible with a wide range of resins



# Summary

- **Glass-ionomer cements**, because of their ability to renew broken bonds, have better cavity-sealing properties and resistance to microleakage over long periods. In addition, because of their ability to leach fluoride, they possess some cariostatic properties. They are particularly suited to the restoration of erosion/abrasion lesions and as dentinal substitutes when resin composite or other restorations are placed and long-term resistance to microleakage is a priority. Their excellent clinical performance has considerable clinical and scientific backing if confined to low-stress-bearing areas, and postoperative sensitivity is reduced particularly where stronger acid etching is employed or faults in the dentinal bonding technique occur.
- **In high-stress-bearing areas or when thin sections of material are required, glass-ionomer cements lack strength** and are easily damaged during function or by early finishing procedures and contamination with moisture. **The modern hybrid and microfilled composites are superior in esthetics, strength, and retention of surface polish where large areas of facial enamel are involved.**
- Dentinal bonding agents have been firmly established for bonding anterior resin composites, porcelain veneers, inlays, and some metal restorations to tooth structure.
- They possess higher bond strengths than do glass-ionomer cements but require greater attention to the preparation of surfaces for bonding. Modern techniques are employing weaker acids, such as maleic acid, to prevent damage to the pulp in the deeper cavity, and these etchants facilitate the formation of a hybrid layer. The success of dentinal bonding is still dependent on the morphology of the dentin, and in areas lacking a high percentage of intertubular dentin, problems can arise.

# Resources

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