Operative Dentistry

Lecture

Caries of dentin
Dentin structure

- The characteristic feature of dentin structure is the dentinal tubules. The dentinal tubules have a hollow structure and they are responsible for dentin permeability. The number and size of dentinal tubules is different at different locations on the dentin. Their course is S-shaped between the junction of dentin and enamel (DEJ) and the pulp, in the crown, and between the junction of dentin and cementum (CDJ) and the pulp, in the root.
The peritubular (sometimes referred to as intra-tubular) dentine is a highly mineralised structure of dentine which has a thickness of approximately 0.5-0.8µm. It is more highly mineralized than intertubular dentine and it contains no organic collagenous fibres in comparison with the intertubular dentine which surrounds it.

Longitudinal-section and cross-section of dentin.
Dentin structure

- The dentinal is a hydrated nano-composite of hydroxyapatite crystallites with diameter of approximately 5 nm in diameter and they are distributed in a scaffold of type-I collagen fibrils, which are around 50-100 nm in diameter, and the remaining parts are fluids and non-collagenous proteins. The hydroxyapatite crystals differ in enamel and dentin, being larger and more regular in enamel than dentin.
Dentin morphology & histology

- Unlike enamel, dentin formation continues after tooth eruption and throughout the life of the pulp. The dentin forming the initial shape of the tooth is called primary dentin and is usually completed 3 years after tooth eruption (for permanent teeth).

- Dentin is located between the enamel or cementum of the external tooth and the pulp internally.
Dentin morphology & histology

- Most of the volume of the tooth is dentin.
- The dentin and the pulp are morphologically and embryologically a single unit.
- It is a hydrated, porous tissue containing dentinal tubules, resulting from the deposition of a collagenous matrix around the cytoplasmic processes of odontoblasts (Tomes' fiber), which subsequently mineralises, encasing the odontoblast processes within the tissue.
- The dentinal tubule allows fluid movement and ion transport necessary for remineralization of intertubular dentin, apposition of peritubular dentin, and/or perception of pain.
Dentin chemical structure

Chemically, dentin composed of approximately 45% inorganic, 33% organic material and 22% water by volume, and approximately 70% inorganic, 20% organic material and 10% water by weight, with different types of dentin expressing different proportions of these and other components.
Dentin permeability

- Dentinal tubules are normally filled with odontoblastic processes and dentinal fluid, a transudate of plasma. When enamel or cementum is removed during tooth preparation, the external seal of dentin is lost and the tubules become fluid-filled channels from the cut surface directly to the pulp. Fortunately, pulpal fluid has a slight positive pressure that forces fluid outward toward any breach in the external seal.
Dentin permeability

- **Dentin permeability is primarily** dependent on the **remaining dentin thickness** (i.e., length of the tubules) and the **diameter** of the tubules. Since the tubules are shorter, become more numerous, and increase in diameter closer to the pulp, **deep dentin is a less-effective pulpal barrier than is superficial dentin** near the dentinoenamel or dentinocemental junctions.
Dentin permeability

Permeability studies of dentin indicate that tubules are functionally much smaller than would be indicated by their measured microscopic dimensions as a result of numerous constrictions along their paths. Dentin permeability is not uniform throughout the tooth. **Coronal dentin is much more permeable than root dentin.** There are also differences within coronal dentin.
Dentin permeability

- Dentine sensitivity is encountered whenever odontoblasts and their processes are stimulated during operative procedures, even though the pain receptor mechanism appears to be within the dentinal tubules near the pulp. A variety of physical, thermal, chemical, bacterial, and traumatic stimuli are transmitted through the dentinal tubules, though the precise mechanism of the transmissive elements of sensation has not been conclusively established.
The most accepted theory of pain transmission is the hydrodynamic theory, which accounts for pain transmission through small, rapid movements of fluid that occur within the dentinal tubules. Because many tubules contain mechanoreceptor nerve endings near the pulp, small fluid movements in the tubules arising from cutting, drying, pressure changes, osmotic shifts, or changes in temperature account for the majority of pain transmission.
Dentin permeability

- The theories of dentin sensitivity are:
  - 1- Theory of thermal shock: it states that the sensitivity results from direct thermal shock to the pulp via temperature changes which transferred from the oral cavity, through the restorative material.
  - 2- A hydrodynamic theory: it is discussed previously.
Dentin permeability

- Dentin must be treated with great care during restorative procedures to minimize damage to the odontoblasts and pulp. Air-water spray should be used whenever cutting with high-speed handpieces to avoid heat buildup. The dentin should not be dehydrated by compressed air blasts; it should always maintain its normal fluid content. Protection is also provided by judicious use of liners, bases, dentin-bonding agents, and nontoxic restorative materials. Restorations must adequately seal the preparation to avoid microleakage and bacterial penetration.
Dentin solubility

- Dentin demineralizes at a pH of 6.5 and lower.
Dentin can be divided into different types according to the site, structure, chemical composition, function and origin. Till now, at least 19 terms to describe different types of dentin: 1. Mantle, 2. primary, 3. secondary, 4. sclerotic, 5. transparent, 6. dead tracts, 7. circumpulpal, 8. centripetal, 9. dystrophic, 10. irregular, 11. irregular secondary, 12. osteodentin, 13. tertiary, 14. irritation, 15. protective, 16. dentin of repair, 17. reparative, 18. interface and 19. reactionary.
Dentin types

- Primary dentin
  - Mantle
  - Circumpulpal
- Secondary dentin
- Tertiary dentin
Dentin types

- Primary dentin: it is the **mineralized zone of dentin** which is gradually mineralized following collagen matrix secretion by the odontoblast cells. This zone lies beneath the **unmeneralized zone of predentin**. Primary dentin forms the primary shape of the tooth and the process of its formation **ends** when teeth become functional and **roots** are **completely formed**.
Dentin types

- Secondary dentin: following complete formation of primary dentin which is generally considered to be after completion of the apical foramen, dentin deposition continues physiologically at a slow rate, without the need for persistent stimuli. A precise point can be determined in time between primary and secondary dentin.
Dentin types

- Tertiary dentin: It has other names such as irritation dentin, irregular dentin or irregular secondary dentin and it is a defensive dentin that protects the pulp. So, it is laid down locally in response to injury or insult and its structure and chemical composition is different from that of primary and secondary dentin in which tertiary dentin displays a more sparse and more irregular tubular pattern in comparison with that of primary and secondary dentin.
Dentin types

- Tertiary dentin is 2 types, reactionary and reparative tertiary dentin, and the former type is produced by odontoblast cells, the same as in primary and secondary dentin. While, the latter is produced by odontoblast-like cells (secondary odontoblast cells or replacement odontoblast cells). Reparative dentin responds to more advanced insult than reactionary dentin.
Dentin types

- Tertiary reactionary dentin: is produced by primary odontoblasts after *minor or chronic injury* of the pulp by pathologic stimulation such as *caries* or other stimuli such as *attrition* and microleakage around restorations.

- Tertiary reparative dentin: is produced by secondary odontoblast cells (odontoblast-like cells) that have differentiated from uncommitted cells in the cell-rich zone of the pulp following the localized death of primary odontoblasts. Localised death of primary odontoblasts results from advanced or moderate insult, such as mechanical pulp exposure due to *cavity preparation*, trauma, *attrition*, abrasion, erosion or *moderate rate dental caries*. 
Dentinal caries

- Maintenance of pulp vitality is dependent on the adequacy of pulpal blood supply. Recently erupted teeth with large pulp chambers and short, wide canals with large apical foramina have a much more favorable prognosis for surviving pulpal inflammation than fully formed teeth with small pulp chambers and small apical foramina.
Dentinal caries

Caries advancement in dentin proceeds through three changes: (1) weak organic acids demineralize the dentin; (2) the organic material of the dentin, particularly collagen, degenerates and dissolves; and (3) the loss of structural integrity is followed by invasion of bacteria.
Dentinal caries

• Five different zones have been described in carious dentin. The zones are most clearly distinguished in slowly advancing lesions. In rapidly progressing caries, the difference between the zones becomes less distinct.

• Zone 1: Normal Dentin. The deepest area is normal dentin.

• Zone 2: Subtransparent Dentin. Next is the subtransparent layer, which is a zone of demineralization of the intertubular dentin and initial formation of very fine crystals in the tubule lumen at the advancing front. Damage to the odontoblastic process is evident; however, no bacteria are found in the zone. Stimulation of the dentin produces pain, and the dentin is capable of remineralization.
Dentinal caries

- Zone 3: Transparent Dentin. The transparent layer is a zone of carious dentin that is softer than normal dentin and shows further loss of mineral from the intertubular dentin and many large crystals in the lumen of the dentinal tubules. Stimulation of this region produces pain. No bacteria are present. Although organic acids attack both the mineral and organic content of the dentin, the collagen cross-linking remains intact in this zone. The intact collagen can serve as a template for remineralization of the intertubular dentin, and thus this region remains capable of self-repair provided the pulp remains vital.
Dentinal caries

- Zone 4: Turbid Dentin. Turbid dentin is the zone of bacterial invasion and is marked by widening and distortion of the dentinal tubules, which are filled with bacteria. There is very little mineral present and the collagen in this zone is irreversibly denatured. The dentin in this zone will not self-repair. This zone cannot be remineralized and must be removed before restoration.
Dentinal caries

- Zone 5: Infected Dentin. The outermost zone, infected dentin, consists of decomposed dentin that is teeming with bacteria. There is no recognizable structure to the dentin and collagen and mineral seem to be absent. Great numbers of bacteria are dispersed in this granular material. Removal of infected dentin is essential to sound, successful restorative procedures as well as prevention of spreading the infection.
**Dentinal caries**

- Inner "affected" dentine
  - few bacteria
  - remineralisable
  - vital
  - sensitive
  - useful

- Outer "infected" dentine
  - bacterial invasion
  - unmineralisable
  - dead
  - without sensation
  - not useful

**Cross-section of tooth with occlusal carious lesion**

**Enlarged cross-section of carious lesion**

**Dentine tubule**
- Necrotic zone
- Contaminated zone
- Demineralised zone
- Translucent zone
- Sound dentine
- Tertiary dentine

**Dentine: Clinical (tactile) manifestations**
- Soft dentine
- (Leathery dentine)
- Firm dentine
- Hard dentine
Dentinal caries

- Removal of the bacterial infection is an essential part of all operative procedures. Because bacteria never penetrate as far as the advancing front of the lesion, it is not necessary to remove all the dentin that has been affected by the caries process. In operative procedures, it is convenient to term dentin as either infected, and thus requires removal, or affected, which does not require removal.
Dentinal caries

- Affected dentin is softened, demineralized dentin that is not yet invaded by bacteria (zones 2 and 3). Infected dentin (zones 4 and 5) is both softened and contaminated with bacteria. It includes the superficial, granular necrotic tissue and the softened, dry, leathery dentin. The outer layer (infected dentin) can be selectively stained in vivo by caries detection solutions such as 1% acid red 52 (acid rhodamine B or food red 106) in propylene glycol. This solution stains the irreversibly denatured collagen in the outer carious layer, but not the reversibly denatured collagen in the inner carious layer.
Dentinal caries

Using this staining technique clinically may provide a more conservative tooth preparation, because the boundary between two layers differentiated by this technique cannot easily be detected tactilely.
Dentinal caries

- In slowly progressing lesion, there may be a zone of hard, hypermineralized **sclerotic** dentin that is the result of remineralization of what formerly was transparent dentin (zone 3).
- When sclerotic dentin is encountered, it represents the ideal final excavation depth because it is a natural barrier that blocks the penetration of **toxins and acids**.
- In this slowly advancing lesions, it is expedient to remove softened dentin until the readily identifiable zone of sclerotic dentin is reached.
Dentinal caries

- Sclerotic dentin has more mineral content than normal dentin. It is usually **shiny and more darkly colored**, but feels hard to the explorer tip. By comparison, normal freshly cut dentin lacks a shiny, reflective surface and allows some penetration from a sharp explorer tip. The apparent function of sclerotic dentin is to wall off a lesion by blocking (sealing) the tubules. The **permeability of sclerotic dentin is greatly reduced** in comparison to normal dentin because of the decrease in the tubule lumen diameter. Therefore it may be more difficult to bond a restorative material to sclerotic dentin.
Dentinal caries

In rapidly advancing lesions, there is little clinical evidence (as determined by texture or color change) to indicate the extent of the infected dentin. For very deep lesions, this lack of clinical evidence may result in an excavation that risks pulp exposure. In a tooth with a deep carious lesion, no history of spontaneous pain, normal responses to thermal stimuli, and a vital pulp (demonstrated by electric testing), a deliberate, incomplete caries excavation may be indicated.
Dentinal caries

- This procedure is termed indirect pulp capping and is characterized by placement of a thin layer of calcium hydroxide on the questionable dentin remaining over the pulp. A direct pulp cap is the placement of calcium hydroxide directly on exposed pulpal tissue (a pulpal exposure) and the surrounding deeply excavated dentinal area. The techniques of indirect and direct pulp capping may stimulate the formation of reparative dentin (dentin bridge).
Dentinal caries

- Different opinions present regarding the indication for indirect pulp capping procedures. Some practitioners routinely remove all softened dentin even if a pulpal exposure is likely. Other practitioners routinely leave a small amount of dentin in the area of a potential pulpal exposure, regardless of the status of such dentin. Finally, some practitioners use the indirect pulp capping technique only when the status of remaining dentin in close proximity to the pulp is questionable.
Dentinal caries

Another controversial issue with the indirect pulp capping treatment is whether or not to reenter the treated tooth at a later time to determine if, in fact, the remaining dentin has remineralized, providing a sound bridge of tooth structure over the affected area. Some practitioners routinely reenter the affected area to verify this remineralization and/or to remove any caries left over the remineralized layer.
Dentinal caries

- Others believe that remineralization will occur and any remaining bacteria become inviable; consequently, reentry into the excavated area is not practical because such a procedure may cause additional pulpal irritation. Carefully controlled studies are lacking, but the consensus is shifting against reentry procedures.
Dentinal caries

Some controversy exists concerning the medication material to place over deeply excavated areas. Although most practitioners recognize the potential for stimulating reparative dentin formation with the use of calcium hydroxide materials, this is not universally accepted. More importantly, there is controversy regarding the mechanism of action for calcium hydroxide liners.
Dentinal caries

- One group of practitioners supports the concept that a calcium hydroxide liner must be in direct contact with pulpal tissue to cause reparative dentin formation. Therefore, these practitioners believe that the use of calcium hydroxide liners in other than a direct pulpal exposure situation will not stimulate reparative dentin formation.
Dentinal caries

However, other practitioners believe that the calcium hydroxide material is soluble and therefore is transmitted by the fluid in the dentinal tubules to the pulp and, consequently, causes reparative dentin formation. Also, as mentioned earlier, the use of resin bonding agents may prove beneficial for pulp capping procedures.
Dentinal caries

Finally, there is minor controversy, or at least confusion, about the terminology related to this procedure. Although this section has termed the procedure caries control restorative treatment, other terms such as interim restoration, treatment restoration, or temporary restoration may be used. All of these descriptions have validity when applied to the technique of removing acute caries without delay and temporarily restoring the involved tooth or teeth.
Dentinal caries

Data are not available to guide the final decision in this area. However, in Advanced Carious Lesions the current use of these techniques is rapidly being replaced with another technique when root canal therapy is not utilized. This newer concept endorses deliberate removal of the coronal pulpal tissue; placement of a calcium hydroxide material over the excavated pulpal area; and then placement of a resin-modified glass-ionomer liner over the calcium hydroxide and surrounding dentin periphery to adequately seal the cavity and provide thermal, mechanical and chemical protection.
Dentinal caries

Although not yet clear, scientific evidence seems to support this trend—the pulpal tissue appears to be disinfected and necrosed by the calcium hydroxide, and the resin-modified glass ionomer appears to adequately seal the area. Both measures may increase the success of a pulp-capping procedure.
Dentinal caries

The restorative procedures involving pulpal therapy are rapidly changing. An excellent bond and seal against microleakage can be achieved by acid-etching the dentinal (as well as enamel) walls of the tooth preparation. This treatment typically is followed by application of a suitable adhesive. Conventional bases are not required, except when thermal or mechanical (against pressure) protection of the pulp is indicated.
Dentin bonding

- Adhesion is a process of solid and/or liquid interaction of one material (adhesive or adherent) with another (adherend) at a single interface. Most instances of dental adhesion also are called dental bonding.

- Most situations involving dental adhesion really involve adhesive joints. An adhesive joint is the result of interactions of a layer of intermediate material (adhesive or adherent) with two surfaces (adherends) producing two adhesive interfaces.
Dentin bonding

- A pit-and-fissure sealant bonded to etched enamel is an illustration of **dental adhesion**. An enamel bonding agent that bonds together etched enamel with composite is a classic dental **adhesive joint**.
- Adhesive bond strength is evaluated by debonding the system.
- Almost all bond strength tests are categorized as **tensile** or **shear bond strengths**.
- Most often the bond strengths of materials are measured by shearing the adhesive or adhesive joint to produce fracture. Bond strength is measured as a single cycle stress to fracture.
Dentin bonding

- Dentin is stronger than composite, which is stronger than the dentin bonding agent. If the interfaces are well bonded, then the fracture occurs **within** the dentin bonding agent or is **driven** into the adherends.
Dentin bonding

- Adhesion is classified as physical, chemical, and/or mechanical bonding.
- Physical bonding involves van der Waals or other electrostatic interactions that are relatively weak.
- Chemical bonding involves bonds between atoms formed across the interface from the adhesive to the adherend. Because the materials are often dissimilar, the extent to which this bonding is possible is limited, and the overall contribution to bond strength is normally quite low.
Dentin bonding

Mechanical bonding is the result of an interface that involves undercuts and other irregularities that produce interlocking of the materials. The microscopic degree to which this occurs dictates the magnitude of the bonding. Almost every case of dental adhesion is based primarily on mechanical bonding. Chemical bonding may occur as well, but generally makes a limited contribution to the overall bond strength. The bonding system copolymerizes with the matrix phase of the composite, producing strong chemical bonding.
Dentin bonding

- The **common method** for producing surface roughness for better mechanical bonding is to **grind or etch** the surface. Gridding produces **gross mechanical roughness** but leaves a smear layer of **hydroxyapatite crystals** and **denatured collagen** that is approximately 1 to 3 um thick. Acid etching (or conditioning) **dissolves** this layer and **produces** microscopic relief with **undercuts** on the surface to create an opportunity for mechanical bonding.
Dentin bonding

To produce **good bonding**, there must be good wetting (wetting is a measure of the energy of interaction of the materials. In the state of complete wetting occurs, the contact angle approaches zero degrees). A second requirement for adhesion is that the surfaces being joined are **clean**.
Dentin bonding

- If the dentin bonding agent is chemically matched to the composite, it will be wet well by the composite, chemically intermix with it, and produce true chemical bonding that will create a very strong interface.

- Dentin is still hydrophilic (water loving). Therefore the dentin bonding agent must be designed to be hydrophilic. This quality produces a chemically intimate and micromechanically well-bonded interface. Most current dentin bonding systems have been designed with etching, priming, and bonding steps to accomplish this.
Dentin bonding

- One way of **improving** the bond strength is to decrease the **adhesive thickness to the point** that a fracture cannot propagate through it in a practical sense. If the adhesive is thin and/or tortuous in geometry, then any crack is constantly driven into one or the other adherends.

- By impregnating a finely etched dentin surface, the final thickness of the dentin bonding agent approaches **1 um**.
Dentin bonding

An alternative approach to improve bonding is to increase considerably the thickness of the bonding system (50 to 100 um) by applying numerous coats of the bonding material. This appears to work by behaving like a stress-relieving liner and increasing the toughness of the system. Clinical trials with systems based on this approach have been very successful over at least 3 years.
Dentin bonding

The problem for dentistry is that different clinical situations may require different chemical characteristics for an adhesive to achieve good wetting. Materials that are good dentin or enamel bonding systems may not necessarily be good porcelain-bonded-to-metal repair bonding agents or amalgam bonding agents.
Dentin bonding

Bonding Systems:

- In dentistry, the agents producing adhesive dental joints are referred to as bonding systems or agents and generally have been classified on the basis of the primary adherend.

Enamel Bonding Systems:

- Enamel bonding systems (or dental bonding systems that also produce enamel bonding) most often consist of an unfilled (or lightly filled) liquid acrylic monomer mixture placed onto acid-etched enamel. The monomer flows into interstices between and within enamel rods.
Dentin bonding

Enamel Bonding Systems:

- Enamel bonding depends on resin tags becoming interlocked with the surface irregularities created by etching.
- Resin tags that form between enamel rod peripheries are called macrotags. A much finer network of thousands of smaller tags form across the end of each rod where individual hydroxyapatite crystals have been dissolved, leaving crypts outlined by residual organic material. These fine tags are called microtags. Macrotags and macrotags are the basis for enamel micromechanical bonding. Microtags are probably more important because of their large number and great surface area of contact.
Dentin bonding

Enamel Bonding Systems:

- During the 1970s and 1980s, before these details were known, bonding studies concentrated more on the length of macrotags and the patterns of etching (Type I = core etching, Type II = periphery etching, Type III = mixed patterns). Macrotag length is unimportant because fracture occurs in the neck of the tag. Most macrotags are only 2 to 5 um in length. Rod etching patterns also are generally not important to the resulting bond strength.
Dentin bonding

Enamel Bonding Systems:

- The macroshear bond strength for the joint is 18 to 22 MPa and is affected by both the film thickness of the bonding system and the shear strength of adjacent enamel rods. The theoretic upper limit for joint strength is probably approximately 50 MPa. The current bond strengths of approximately 20 MPa appear to be acceptable clinically. More than 20 years of clinical monitoring has not revealed any significant degradation of the mechanical bonds due to fatigue.
Dentin bonding

Dentin Bonding Systems:

- Dentin bonding systems involve an unfilled (or lightly filled) liquid acrylic monomer mixture placed onto an acid-etched and primed dentin surface. The bonding primer depends on hydrophilic monomers such as 2-hydroxyethyl methacrylate (2-HEMA or HEMA), to easily wet hydrophilic dentin surfaces that contain some moisture. Although primer and/or bonding agent may flow into dentinal tubules, the bond strength is primarily achieved by micromechanical bonding to the intertubular dentin (between tubules) along the cut dentin surface.
Dentin Bonding Systems:

- The reliable dentin bonding of composite restorations has been a difficult goal for dental manufacturers. While, some manufacturers claim their products create chemical bonds to dentin, most experts agree that the primary mechanism of attachment is mechanical interlocking.
Dentin Bonding Systems:

- Despite the fact that many dentin bonding systems have been formulated to allow chemical reactions to take place with dentin, this has had little or no apparent contribution on the final bond strength. Generally, 90% or more of dentin bond strength is presumed to be due to mechanical bonding.
Dentin bonding

Dentin Bonding Systems:

- As noted earlier, **mechanical preparation of dentin** leaves behind a highly distorted debris layer (**smear layer**) that covers the surface and conceals the underlying structures.

- So, whenever dentin has been cut or abraded, a thin altered layer is created on the surface. This smear layer is only a few micrometers thick and is composed of denatured collagen, hydroxyapatite, and other cutting debris.
Dentin bonding

Dentin Bonding Systems:

- The smear layer serves as a natural bandage over the cut dentinal surface because it occludes many of the dentinal tubules with debris called smear plugs. While, the smear layer is a good protective barrier, it has a relatively weak attachment to the dentin and is subject to dissolution by acids.
Dentin bonding

Dentin Bonding Systems:

- Most dentin-bonding systems have acids that remove the smear layer and partially demineralize the intertubular dentin. In most systems these acidic components are weaker than the 37% phosphoric acid commonly used to etch enamel surfaces. When viewed under high magnification, dentin without a smear has many irregularities for micromechanical retention.
Dentin bonding

Dentin Bonding Systems:

- Ideally, such etchants remove the smear layer but leave the smear plugs because they greatly reduce dentin permeability and sensitivity. Etchants should not excessively damage exposed collagen fibers because much of the bond strength develops from resin encapsulating these fibers.
Dentin Bonding Systems:

- After the acids, hydrophilic adhesive resins are applied that penetrate into the inherently moist dentin surfaces and copolymerize with the composite restoration. While some of the bond forms from resin "tags" extending into the dentinal tubules, most of the bond strength develops from resin that penetrates and adapts to the demineralized intertubular dentin and exposed collagen fibers. The resultant resin interdiffusion zone is often termed the hybrid layer.
Dentin bonding

Dentin Bonding Systems:

- While, dentin bond strengths have improved, they are variable because of the dentin substrate. Bond strengths for superficial dentin close to the dentinoenamel or dentinocemental junctions are greater than those for deep dentin. In deep dentin the greater number of tubules and the larger diameter of tubules reduce the amount of intertubular dentin available for bonding.
Dentin Bonding Systems:

- An important aspect of current dentin-bonding agents is their ability to seal cut dentinal surfaces and thus reduce permeability and microleakage. Many dentists use dentin-bonding products to seal and desensitize dentin surfaces in all tooth preparations and in unrestored Class V cervical abrasion and erosion defects.
Dentin bonding

Dentin Bonding Systems:

- Early dentin bonding systems were hydrophobic and were bonded directly to the dentin smear layer. Therefore macroshear bond strengths were found to be less than 6 MPa, because that is the strength of the bond of the smear layer to sound dentin. Initial dentin etching processes removed the smear layer, but tended to overetch dentin.
Dentin Bonding Systems:

- Bond strengths of 10 to 12 MPa were produced, and were not significantly increased until bonding systems were chemically modified to become more hydrophilic (18 to 20 MPa). Careful dentin etching produced micromechanical relief for bonding between tubules (intertubular dentin) without excessive demineralization of peritubular dentin. Coupled with hydrophilic primers, bond strengths increased to 22 to 35 MPa.
Dentin Bonding Systems:

- The theoretic limit for dentin bonding system strength may actually be higher (80 to 100 MPa) than that for enamel, because dentin is more resistant to shear fracture. The clinically important limit for dentin bonding is not yet known. However, because of the presence of more water in dentin than enamel, the clinical longevity of dentin bonding may not be as long as that of enamel.
Dentin bonding

Dentin Bonding Systems:

- The priming action in dentin bonding systems is designed to penetrate through any remnant smear layer and into the intertubular dentin and to fill the spaces left by dissolved hydroxyapatite crystals. This allows acrylic monomers to form an interpenetrating network around dentin collagen. Once polymerized, this layer produces what Nakabayashi referred to as the hybrid zone interdiffusion zone or interpenetration zone. Depending on the particular chemistry of a bonding system, the hybrid layer may vary from 0.1 to 5 um deep.
Dentin bonding

Dentin Bonding Systems:

- Unfortunately, excessive etching may decalcify dentin from 1 to 10 μm deep. If this decalcified dentin zone is not filled (bonded) by bonding system, it may act as a weakened layer or zone contributing to fracture. In addition, the extent of the etching effect on the strength of the collagen fibers is not yet known. However, these systems demonstrate that stronger dentin bonding is possible and portend a bright future for bonding systems.
Dentin bonding

Dentin Bonding Systems:

- The key ingredient for priming in many dentin bonding systems is hydroxyethyl methacrylate (HEMA). This molecule is an analog to methyl methacrylate, except that the pendant methyl ester is replaced by an ethoxy ester group to make it hydrophilic. Importantly, it is relatively volatile and has some tendency to produce mild sensitivity.
Dentin bonding

Dentin Bonding Systems:

- Dentists and assistants should be aware that it is very mobile, can diffuse through rubber gloves, and will cause skin dryness and cracking in many individuals. Therefore, during the use of primers and bonding agents, high-volume evacuation should be used to minimize HEMA vapor contact.
Dentin bonding

Dentin Bonding Systems:

- Bonding normally has been conducted in three steps (three-component systems). During the late 1990s, the number of stages (etching, priming, bonding) was reduced by combining the actions of various steps. Two-component systems were devised that either employed etching with priming/bonding or etching/priming with bonding. In the latter case, the term self-etching primer was used to describe the first component of the system.
Dentin Bonding Systems:
• This is most often achieved by employing acidic monomers that dissolve or disrupt the smear layer, dissolve hydroxyapatite in the intertubular zone and tubules, and then polymerize to generate a hybrid zone. Despite the approach to designing two-component systems, they generally required significant solvent to cosolubilize the modifying material. Solvent levels among systems vary considerably but are generally in the range of 65% to 90% solvent. Choices for solvent systems, based on acetone or ethanol with water, do affect the wetting efficiency.
Dentin bonding

Dentin Bonding Systems:

- For bonding systems to efficiently produce a hybrid layer, it is extremely important to keep the dentin hydrated. Quite often, the rinsing and drying of dentin that follows tooth preparation or specific etching steps, results in dehydrated superficial layers of dentin. Etched dentin no longer contains hydroxyapatite crystals between collagen fibers. It consists only of the remaining collagen and water.
Dentin bonding

Dentin Bonding Systems:

- Dehydration, whether intentional or not, causes the remaining collagen sponge to collapse with collagen molecules forming a mat and excluding monomers necessary for hybrid layer formation. Therefore etched dentin either must be kept moist or be intentionally rehydrated.
Dentin bonding

Dentin Bonding Systems:

- Rehydration can be accomplished with a moist cotton pledget or applicator tip in contact with the surfaces for approximately 10 seconds or by the use of rewetting agents. If dentin moisture is inadequate, then the hybrid layer will not form, and the bonding system will fail to seal and bond. It is suspected that inadequate precautions in this regard in many bonding instructions during the early 1990s may have contributed to the premature failure of many dentin bonding systems.
Dentin Bonding Systems:

- The latest dentin bonding systems combine all three stages of dentin bonding into a single component (one-component system). This approach provides a much simpler procedure for bonding to enamel and dentin, but is not necessarily well designed to wet and bond onto other substrates such as ceramic, composite, or amalgam. Therefore, three-component systems, which allow procedural modifications to accommodate for differences in substrate properties (multipurpose bonding systems), may continue to be used. It is extremely challenging to create a truly universal one-component bonding system that performs well in all possible bonding situations.
Dentin bonding

Other indications for dentin adhesive:

- Desensitization of dentin.
- Amalgam Bonding Systems.
- Indirect Adhesive restorations.
- Bonding orthodontic brackets.
Dentin during operative procedure

During tooth preparation, dentin is distinguished from enamel by:

- **Color:** dentin is normally yellow-white and slightly darker than enamel, in older patients dentin is darker and become brown or black in cases in which it has been exposed to oral fluids, old restorative materials or slowly advancing caries.

- **Reflectance:** dentin surfaces are more opaque and dull, being less reflective to light than enamel surfaces which appear shiny.
Dentin during operative procedure

During tooth preparation, dentin is distinguished from enamel by:

- **Hardness**: dentin is softer than enamel, sharp explorer tends to catch and hold in dentin.

- **Sound**: when moving an explorer tip over the tooth, enamel surfaces provide a sharper, higher pitched sound than dentin surfaces.
Great Thanks