Sri Aurobindo College of Dentistry

Indore, Madhya Pradesh

INDIA

Module plan

- Topic : ROLE OF SMEAR LAYER IN RESTORATIVE DENTISTRY
- Subject: DEPT. OF CONSERVATIVE DENTISTRY AND ENDODONTICS
- Target Group: Undergraduate Dentistry
- Mode: Powerpoint – Webinar
- Platform: Institutional LMS
- Presenter: DR. SWADHIN RAGHUWANSHI

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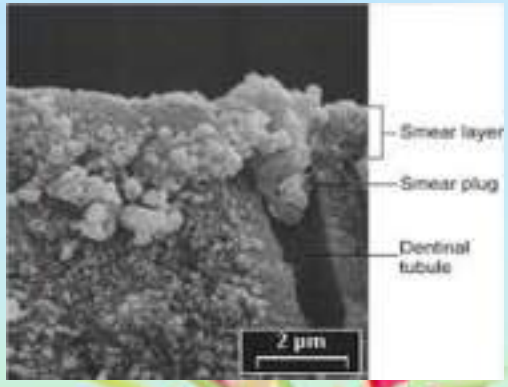
INTRODUCTION

- The term smear layer is used to describe the grinding debris left on dentin by cavity preparation.
- However, the term applies to any debris produced iatrogenically by the cutting, not only of dentin, but also of enamel, cementum and even the dentin of the root canal.

INTRODUCTION

- When tooth structure is cut with either hand instrument or rotary instruments, instead of being uniformly sheared or cleaved the mineralized matrix shatters.
- Existing at the strategic interface of restorative materials and the dentin matrix, most of the debris is scattered over the enamel and dentin surfaces to form the smear layer.



DEFINITION

- Tooth preparation with rotary instruments generates cutting debris, some of which is compacted unavoidably into a layer on the cut surface. That layer of material is called a smear layer. – **Sturdevant**
- If dentine is cut or polished during dental treatment the tubule orifices become, at least partially, occluded with debris called smear layer. – **Graham J Mount**
- Tenacious deposit of microscopic debris that covers enamel and dentin surfaces that have been prepared for a restoration. – **Anusavice**

HISTORY

- Boyde, Switsur and Stewart in 1963 first named the grinding debris as smear layer under scanning electron microscope.
- Such layer was readily removed with NaOCl leading them to conclude that an organic layer containing apatite crystals was deposited or smeared on the enamel due to melting of tissues by the frictional heat generated during cutting.
- They believed that enamel was the source of the smeared components.

HISTORY

- Provenza and Sardana in 1966 reported variations in the degree to which debris was removed.
- Nelsen and Zisman in 1966 described the dynamics of cutting dental tissues and appeared to imply the existence of an altered surface layer due to elastic and plastic deformation of the tissue.
- Eick and his co-workers in 1970 identified the cutting debris on smooth surface and accounted for the formation of smear layer especially in dentin by a brittle and ductile transition and alternating rupture and transfer of apatite and collagen matrix into the surface.

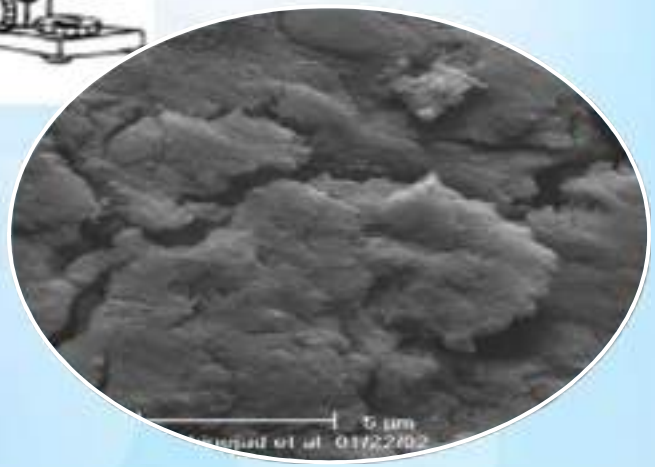
HISTORY

- They confirmed that surfaces abraded with diamonds were rougher than those cut with tungsten carbide burs, surfaces cut dry were rougher and more smeared than those in which water was used as coolant.
- The smear layer is composed of an organic film less than 0.5mm thick with particles of apatite ranging from 0.5 to 15µm. Such layers were present on all cut surfaces though they were not necessarily continuous.

SMEAR LAYER FORMATION

Shattered debris

Smear layer

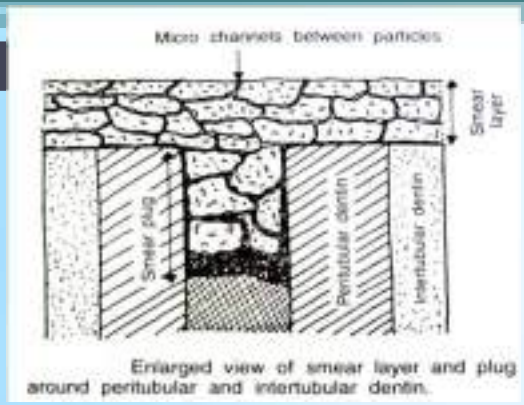


- Identification of the smear layer was made possible with scanning electron microscope, and first reported by **Eick *et al.* (1970)**.
- These workers showed that the smear layer was made of particles ranging in size from less than 0.5-15 µm.

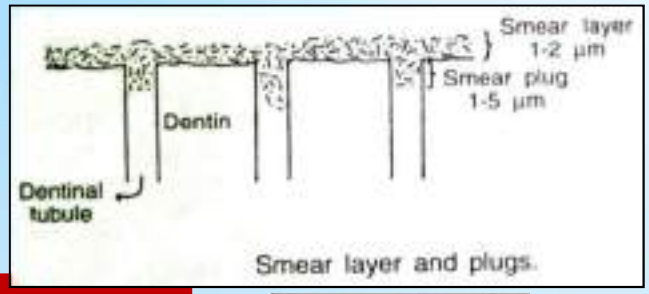
The smear layer has an amorphous, irregular and granular appearance when viewed under the SEM.

STRUCTURE AND COMPONENT
LAYER

Cameron (1983) and Mader *ct. al* (I984)



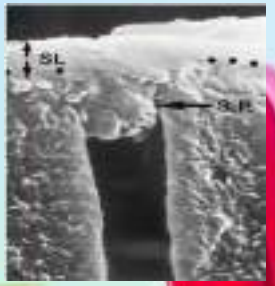
Enlarged view of smear layer and plug around peritubular and intertubular dentin.



Smear layer and plugs.

Superficial smear layer – loosely attached to the underlying dentin

Debris plugs into the dentinal tubule openings



STRUCTURE AND COMPONENTS OF SMEAR LAYER

- Dentin is also composed of two different layers → Superficial dentin, Deep dentin
- Smear layer found on deep dentin contain more organic material than those found on superficial dentin.
- The adhesive strength of all cements is always 50% greater in superficial dentin.
- This may indicate that the quality and quantity of smear layer found on superficial dentin may be greater than that produced in deep dentin.

STRUCTURE AND COMPONENTS OF SMEAR LAYER

- Cenzig et al 1990 proposed that the components of the smear layer can be forced into the dentinal tubules to varying distance as a result of linear movement rotation of instruments and because of capillary action generated between the dentinal tubules and the smear material.

COMPOSITION OF SMEAR LAYER

- The exact proportionate composition of the smear layer has not yet been determined, but scanning electron microscope examinations have disclosed that its composition is both organic and inorganic.
- The inorganic material in the smear layer is made up of **tooth structure and some nonspecific inorganic contaminants.**
- The organic components may consist of heated coagulated proteins (gelatin formed by the deterioration of collagen heated by cutting temperatures), saliva, blood cells, **and in cases of root canal, necrotic or viable pulp tissue.**

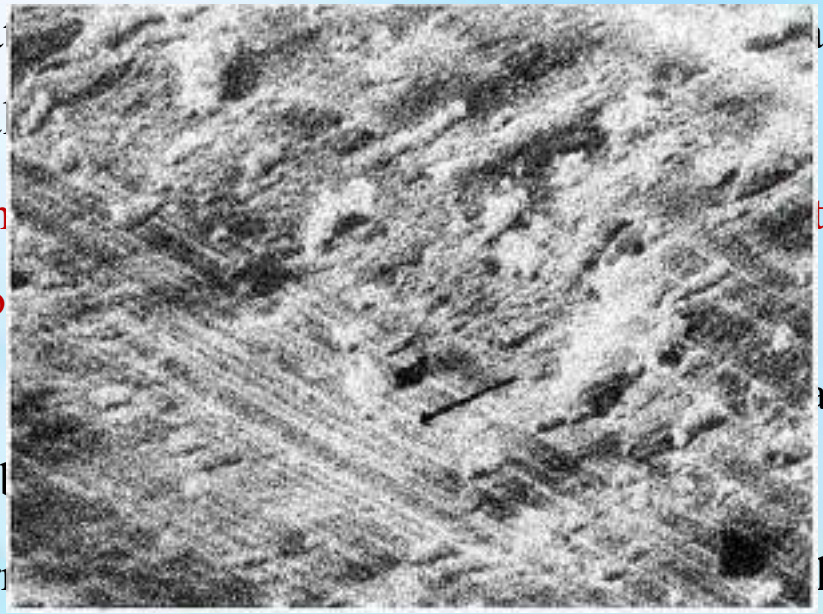
FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

- Variation exists in smear formation by the type of instrument used and the condition under which it is used.
- The differences in topographical detail after cutting dentin and enamel with steel and tungsten carbide burs and abrading it with diamond stones are clearly evident.

FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

- Steel and tungsten carbide burs produce an undulating pattern, the troughs of which run perpendicular with the ece.
- Fine grooves can be seen s and parallel with the direction of rotation led galling and the frictional humps represent e.
- The galling phenomenon carbide burs run at high speed.

FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

- At higher magnifica  n be seen to have obliterated the norma
- Debris irregular in sh tion, remains on the surface even after tho
- Discontinuities exist t are formed in the tissue by tearing and
- Some portions – fir have lifted free by delamination.

FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

- Diamond points unlik lentinal surface by abrading action.
- Abrasive particles pass troughs in which substrate is ejected ahead of the a into ridges parallel with the direction of travel of pa
- Several factors govern ing particle size, pressure and hardness of the abrasive relative to the substrate.

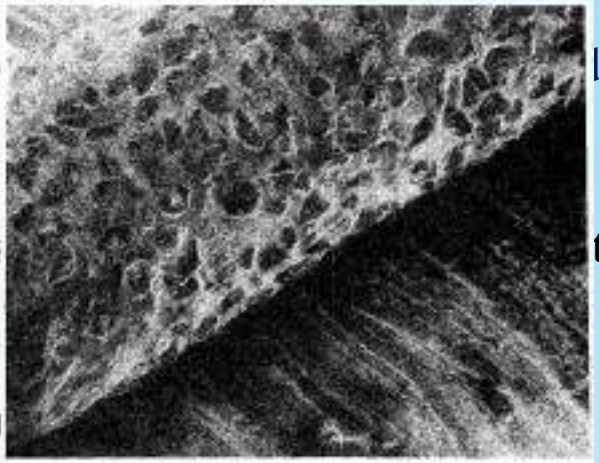


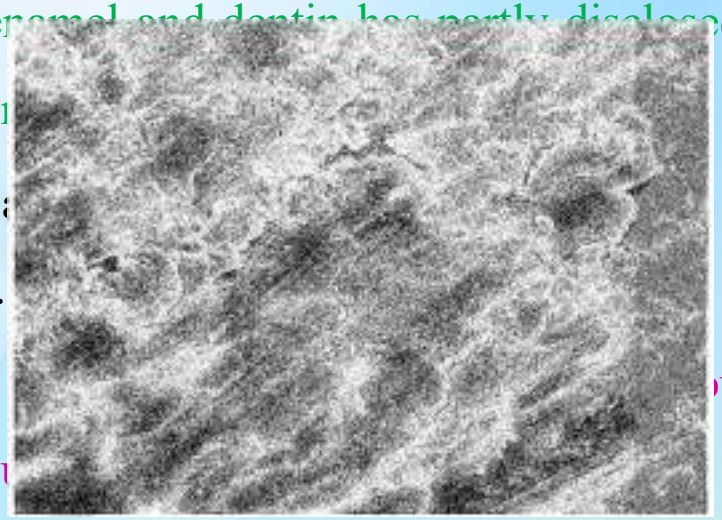
FIG 6. *Scanning electron micrograph of a diamond stone in situ. Note the abrasive particles and the grooves left by them in the tissue. X15.*

FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

- At higher mag ep grooves, which are often discontinuous lized brittle fracture of the tissue.
- There was nc he dentin or the prismatic content of ena used.
- Other abrasive appear similar to diamonds in their topogr

FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

- Following the use of fine abrasives, such as fine diamond and silicon carbide, the structure of both enamel and dentin has partly disclosed though the tubules of the dentin were frequen



- If the diamond is a the smear layer appears to cover a wider area.
- Coolant of water ut significantly reduce the amount and distribu

FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

Sharpness of cutting instrument

- The duller the instrument more is the thickness of the smear layer.

Whether dentin is cut dry or wet

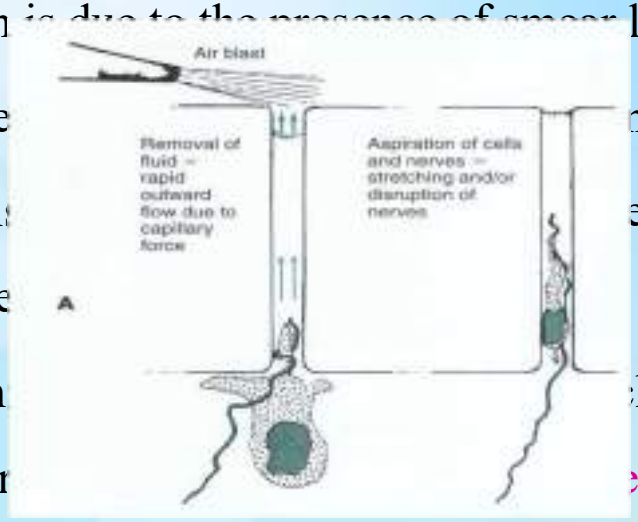
- Brannstrom and Nordenvall in 1979 reported that cutting without water produces thicker smear layer.

FACTORS AFFECTING THE FORMATION OF SMEAR LAYER

- Thick smear layer - Cutting without water spray
  - Coarse diamond bur
  - Rotary cutting instruments
- Thin smear layer - Copious spray of air and water
  - Carbide fissure burs
  - Hand cutting instruments

DENTINAL FLUID MOVEMENT AND SMEAR LAYER

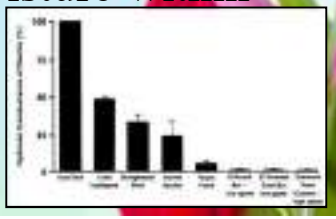
- Pashley and Livingston in 1978 indicated that most of resistance to the flow of fluid across dentin is due to the presence of smear layer.
- Etching dentin gre nt across dentin.
- This is accompli ensitivity of dentin to osmotic, thermal and tactile
- The ease with wh hed dentin (dentin free of smear layer) can be deter .



DENTINAL FLUID MOVEMENT AND SMEAR LAYER

$$\text{Hydraulic conductance} = \frac{\text{Value of fluid in } \mu l}{\text{Surface area } (cm^2) \times \text{time(min)} \times \text{pressure gradient}}$$

- Movement of fluid across dentin meets a resistance directly proportional to the quality and quantity of smear layer present.
- In vital teeth, the smear layer restricts the dentinal fluid from flushing the dentin surface – hinders the process of marginal sealing.
- In non-vital teeth, marginal seal is improved because of the lack of moisture within the dentinal tubules.



DENTINAL FLUID MOVEMENT AND SMEAR LAYER

- Etching the dentin of roots, therapeutically or by the action of micro-organisms of plaque, removes the thin layer of covering cementum or smear layer or both .
- Conditioning with acids removes the smear layer plugs exposing patent dentinal tubules to the oral cavity - Causes sensitivity.

DENTINAL FLUID MOVEMENT AND SMEAR LAYER

- According to the hydrodynamic theory of dentin sensitivity, for sensitivity, the dentinal tubule must be patent and must allow movement of fluid across dentin.
- Causes bacterial products from plaque to permeate into the pulp
- Smear layer acts as a barrier for micro organisms but causes slow passage of bacterial products causing mild, low grade inflammatory response - Lowers the pain threshold in the affected teeth, making them more sensitive.

ROLE IN CEMENTATION OF INDIRECT RESTORATIONS

- Much less pressure is required to force fluid across etched dentin – one should not purposely etch dentin prior to cementing castings.
- Whenever castings are cemented into place, patients are asked to bite down a cotton roll or seating aid that places all of the masticatory force on that tooth generating around 20kg/cm^2 of force on the casting.
- Since the cement is an incompressible liquid, it will transfer this pressure to fluid of dentin – responsible for pain and senstivity.

ROLE IN CEMENTATION OF INDIRECT RESTORATIONS

- When cements reacts chemically with the smear layer rather than with the matrix of sound intertubular dentin, produces a weaker bond as the smear layer can be torn away from the underlying matrix.
- When cements are applied to dentin covered with a smear layer, then tested for tensile strength, the failure can be between adhesive or between constituents of the smear layer.

INFLUENCE ON PERMEABILITY OF CORONAL DENTIN

Reasons cited for retaining smear layer

- Physical barrier preventing ingress of bacteria and their products into underlying dentin.
- Lowers dentin permeability(pashley et al 1991 reported 86% ↓ in permeability).

Reasons cited for removal

- Smear layer itself may contain bacteria

INFLUENCE ON THE PERMEABILITY OF CORONAL DENTIN

- Substances diffuse across dentin at a rate that is directly proportional to their concentration gradient and the surface area available for diffusion.
- The area available for diffusion in dentin was determined by the density of dentinal tubules, i.e., the number of tubules per sq mm, and by the diameter of these tubules.
- The actual area of diffusional surface was the product of tubule density and the area of each tubule(1% at DEJ to 22% at the pulp).

INFLUENCE ON THE PERMEABILITY OF CORONAL DENTIN

Area of Surface of Dentin Available for Diffusion at Various Distances from the Pulp

Distance from Pulp	Number of Tubules million cm^{-2}		Tubular Radius cm x 10^{-4}		Area of Surface (Ap) %	
mm	mean	range	mean	range	mean	range
Pulp	4.5	3.0-5.2	1.25	2.0-3.2	22.1	9-42
0.1-0.5	4.3	2.2-5.9	0.95	1.0-2.3	12.2	2-25
0.6-1.0	3.8	1.6-4.7	0.80	1.0-1.6	7.6	1-9.0
1.1-1.5	3.5	2.1-4.7	0.60	0.9-1.5	4.0	1-8.0
1.6-2.0	3.0	1.2-4.7	0.55	0.8-1.6	2.9	1-9.0
2.1-2.5	2.3	1.1-3.6	0.45	0.6-1.3	1.5	0.3-6
2.6-3.0	2.0	0.7-4.0	0.40	0.5-1.4	1.1	0.1-6
3.1-3.5	1.9	1.0-2.5	0.40	0.5-1.2	1.0	0.2-3

Modified from Garberoglio and Brännström (1976).
$Ap = N\pi r^2$ where N is the number of tubules/cm^2; Ap represents the percent of the total area of the physical surface available for diffusion.

INFLUENCE ON THE PERMEABILITY OF CORONAL DENTIN

Diffusion	Convection
Occurs from areas of higher concentration to lower.	Transport of materials across dentin is due to the presence of a pressure gradient.
The concentration of substances is dissipated over a distance.	There is no change in the concentration of substances dissolved in the fluid because the fluid and all that is dissolved in it is made to flow from one point to another. The driving force is pressure.
Varie… cross…	…dius

Movement of fluid across dentin by convection is much more sensitive to the degree of occlusion of tubules, in the presence or absence of a smear layer, than is the movement of substances by diffusion.

INFLUENCE ON THE PERMEABILITY OF CORONAL DENTIN

POISEUILLE - HAGEN LAW

- $Q = \frac{\pi \Delta P r^4}{8 \eta l}$

Q = Rate of fluid flow

r= Tubule radius

ΔP = Hydrostatic pressure gradient

L = length of tubule

Ŋ = viscosity of dentinal fluid

- Presence of the smear layer has a profound effect on the resistance to movement of fluid across dentin by modifying the tubular radius.

INFLUENCE ON THE PERMEABILITY OF CORONAL DENTIN

- If the smear layer is thick, the initial permeability of dentin will be low but should increase more after etching.
- Teeth that have little or no smear layer will have high initial permeabilities, which will not change much following etching since there is little debris occluding the tubules.
- Therefore, the magnitude of the change in the rate of flow of fluid across dentin before and after etching indicates the thickness or density of the smear layer.

BACTERIAL ASSOCIATION OF SMEAR LAYER

- Dentinal tubules originating from a cavity not only lead to the pulp.
- Tubules on the side walls of the cavity may also lead outward toward the enamel or to the root cementum.
- These tubules are filled with fluid and viable bacteria may sometimes enter these tubules from a liquid-filled gap under a restoration.
- Bacteria may multiply on cavity walls if there was no appreciable communication to the oral cavity – may get nourishment from the smear layer and dentinal fluid.

BACTERIAL ASSOCIATION OF SMEAR LAYER

- These considerations favor the opinion that most of the smear layer should be removed and any smear layer remaining for instance at the tubule apertures, should b pplica
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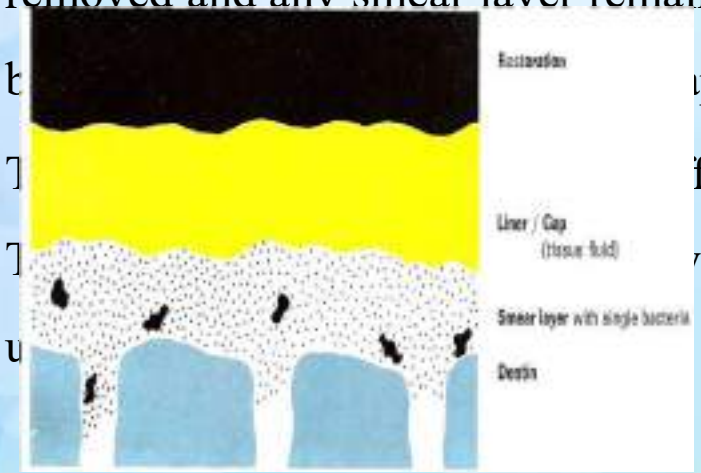
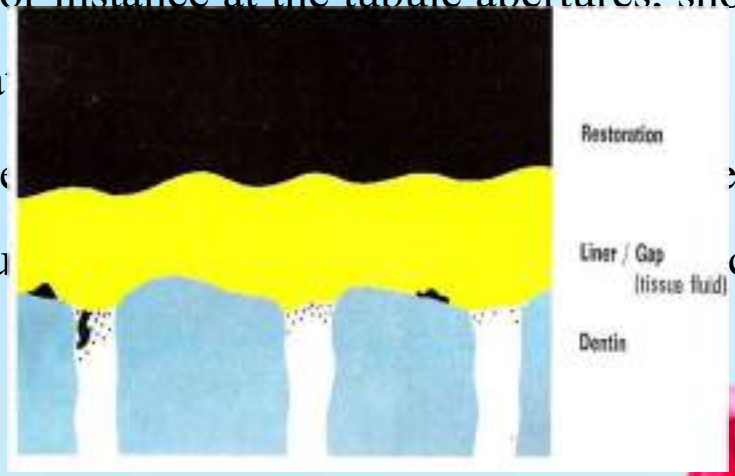
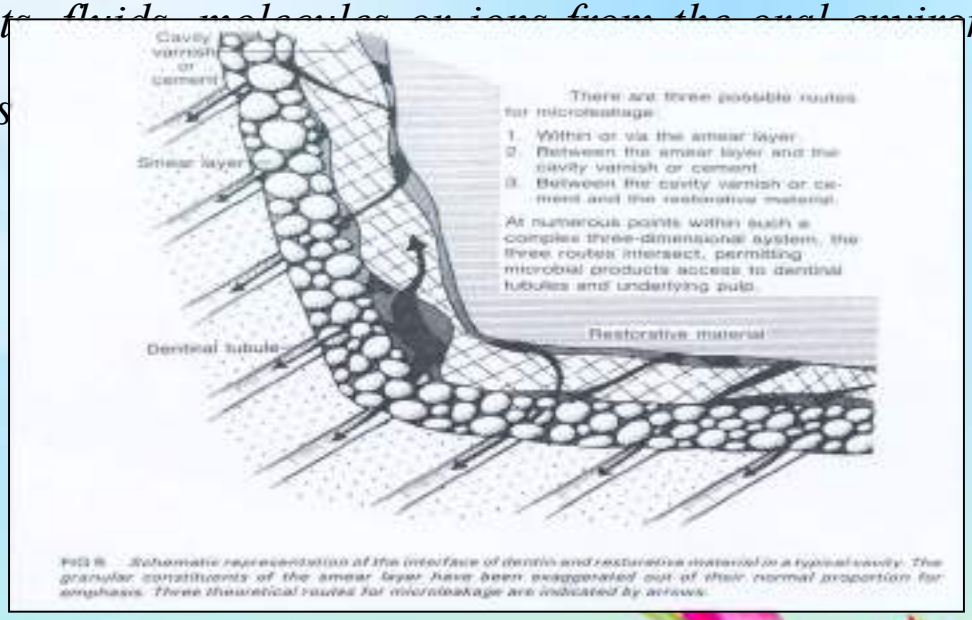




BACTERIAL ASSOCIATION OF SMEAR LAYER

- *Microleakage* can be defined as *'the clinically undetectable passage of bacteria and bacterial products, fluids, molecules or ions from the oral environment along the various gaps pres*



BACTERIAL ASSOCIATION OF SMEAR LAYER

- Bergenholtz et.al (1982) found that microbial invasion occurred more frequently around amalgam restorations.
- These observations recommended that all cavity walls should not only be cleaned and antiseptically treated but also protected with a thin lining.
- The lining should not be placed over a superficial smear layer on the surface of cut enamel and dentin, as a thin lining may be insufficiently antibacterial.
- Moreover for adequate retention of the lining to the cut enamel and dentin, a superficial smear layer must not be present.

BACTERIAL ASSOCIATION OF SMEAR LAYER

- Bases of zinc oxide eugenol and calcium hydroxide may have good antiseptic effects but, unfortunately, under permanent restorations these bases cannot be placed on all cavity walls.
- Also, bases of calcium hydroxide, such as Dycal, may disappear when leakage occurs, leaving a fluid space for bacteria to enter.
- Bases of fast-setting calcium hydroxide may attach poorly to the cut surface and there is the risk that a fluid-filled gap may develop on both sides of the lining.

SMEAR LAYER ON DENTIN EXPOSED TO THE ORAL CAVITY

- Smear layer on surfaces exposed to the oral cavity and left unrestored, for example, in root planing, after superficial grinding, or under poorly fitting temporary crowns.
- Smear layer disappears after a couple of days and is replaced by bacteria, and after a week almost all tubules are opened and some even widened.
- Bacteria may plug the apertures of the tubules. After two weeks, however, we have occasionally seen a mineralized pellicle blocking the apertures of the tubules.

The Protective Effect of Smear Plugs in Tubule Apertures and the Consequence of Removing the Plugs

- Smear plugs in the apertures of the tubules prevents bacterial invasion, but did not prevent bacterial toxins from diffusing into the pulp.
- The degree of inflammation in the pulp seems to **depend on the amount and type of toxin, from both live and dead bacteria,** reaching the pulp, rather than the presence of bacteria within the tubules.
- From opened tubules, bacteria may easily reach the pulp and multiply. Therefore, removal of smear plugs should be avoided.

The Protective Effect of Smear Plugs in Tubule Apertures and the Consequence of Removing the Plugs

- Another important consequence of etching and the removal of smear plugs and peritubular dentin at the surface is that the area of wet tubules may increase from about 10 to 25% of the total.
- Subsequently it is difficult to get the dentin dry because fluid continues to be supplied from below through the tubules. This moisture would not seem to favor adhesive or mechanical bonding to dentin.

The Protective Effect of Smear Plugs in Tubule Apertures and the Consequence of Removing the Plugs

- Drying is not a problem in eroded or abraded dentin, where the tubules usually are occluded by sclerosis.
- However, in sensitive dentin, the tubules are open all the way. It is better to keep them occluded with disinfected smear and with peritubular dentin preserved at the surface.

TREATMENT CONSIDERATIONS

Role of smear layer in dentin bonding

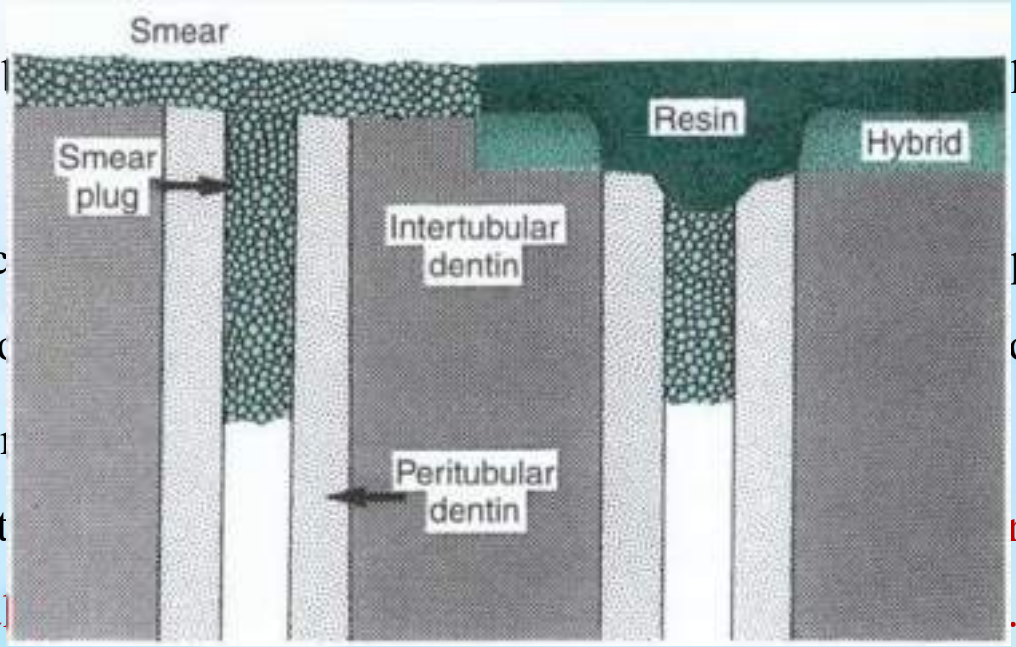
Reasons cited for retaining smear layer

- Prevents decrease in bond strength seen with some bonding systems as deeper dentin is prepared
- Lowers the effect of pulpal pressure on bond strength.

Reasons cited for removal

- Deterrent to bonding process,barrier to penetration of resin to underlying dentin substrate.

SMEAR LAYER AND BONDING



- Most dentin l layer and partially demineralize
- After the ac penetrate into the inherently mo osite restoration.
- Although so into the dentinal tubules, most rates and adapts to the demineral .
- The resultant resin interdiffusion zone is often termed as the hybrid layer.

Current adhesion strategies

- **Smear layer modifying adhesives.**
- **Smear layer removing adhesives.**
- **Smear layer dissolving adhesives.**

Smear layer modifying adhesives

- Adhesives modify the smear layer and incorporate it into the bonding process.
- The smear layer in this adhesion process is retained based on the concept that it serves as a natural barrier to the pulp, prevents bacterial invasion and limits the outward flow of pulpal fluid that might impair bonding efficiency.
- Penetration of monomers into the smear layer and their subsequent polymerization **reinforces the attachment of the smear layer to the underlying dentin** and also forms a micromechanical and perhaps a chemical bond to the underlying dentinal surface.

Smear layer modifying adhesives

- The shallow interaction of the adhesive system with dentin, without any collagen fibril exposure, confirms the weak acidity of these smear layer modifying agents.
- The dentinal tubules commonly remain plugged by smear debris.
- Ex All Bond 2 and Prime and Bond 2.

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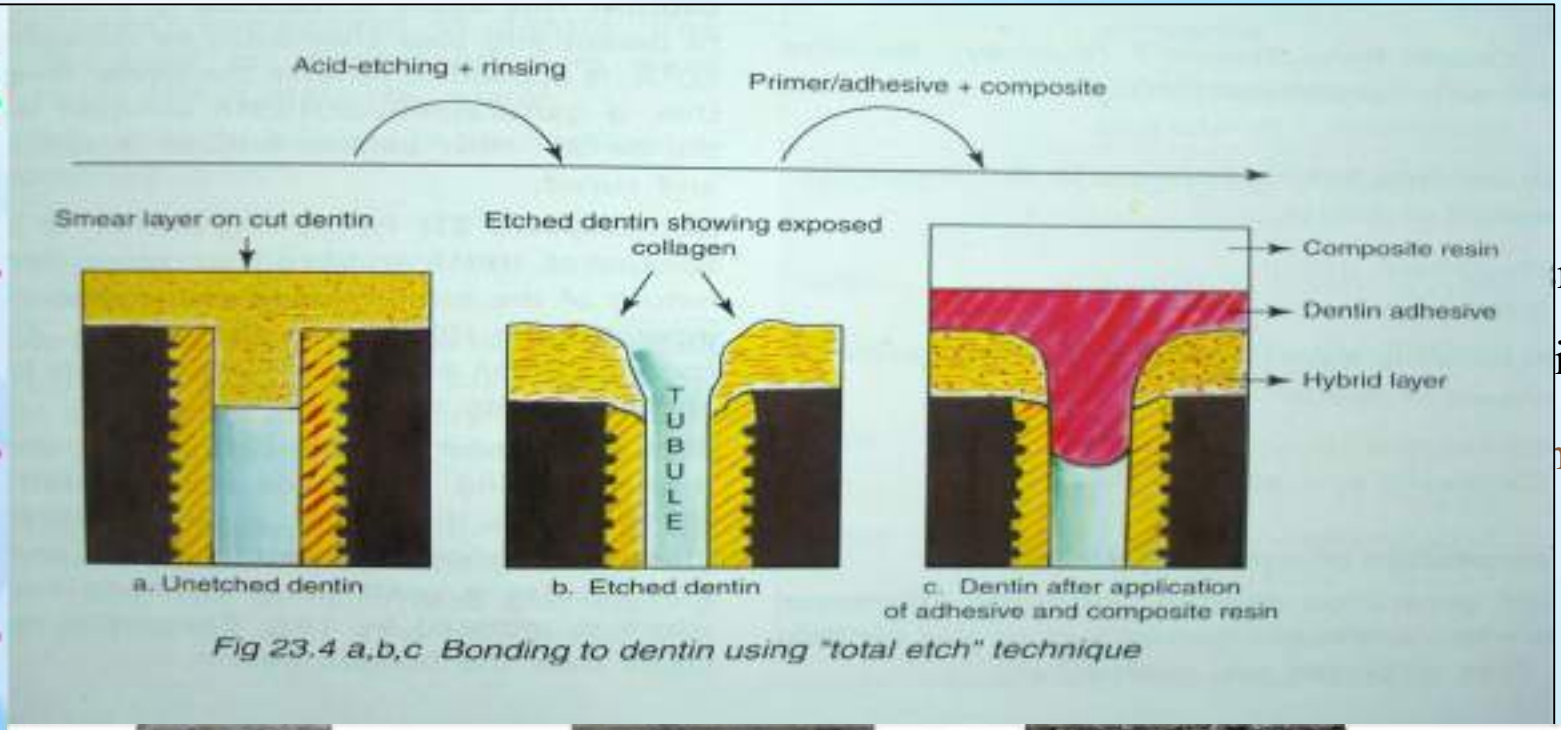

Fig 23.4 a,b,c Bonding to dentin using "total etch" technique

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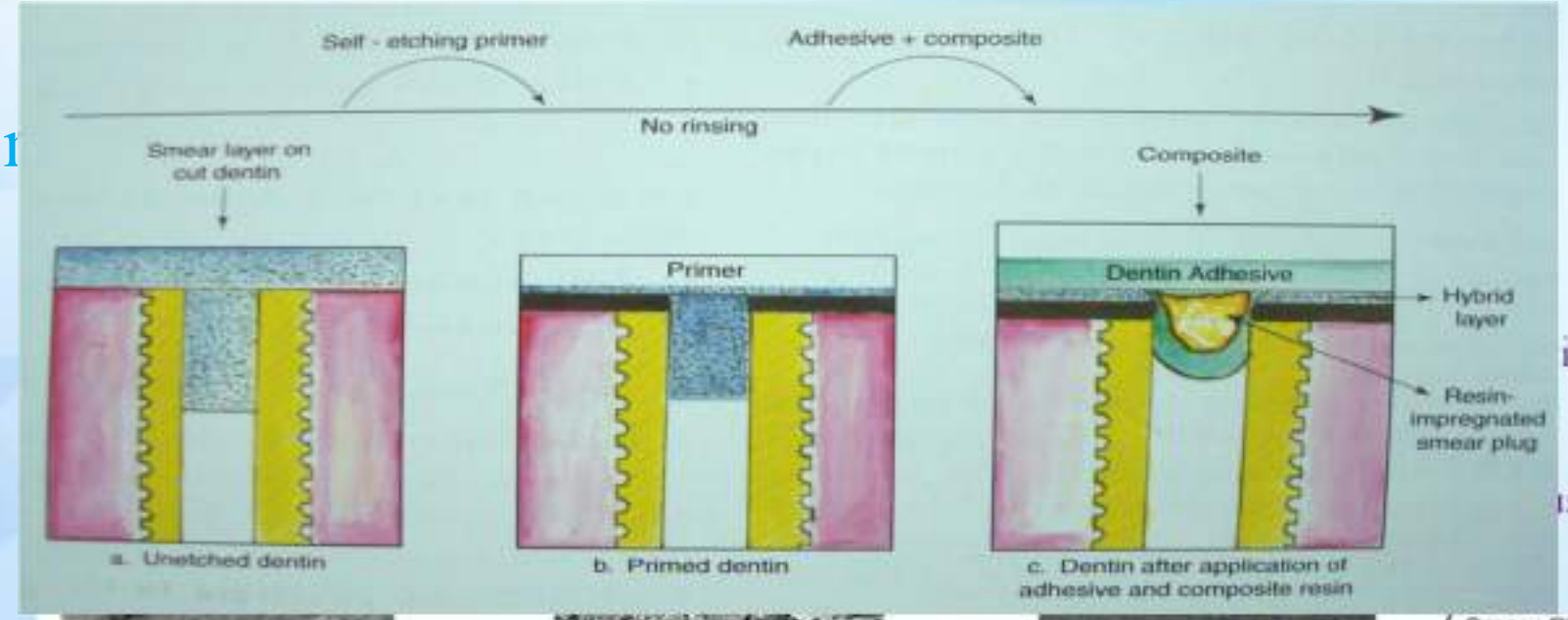

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hybrid layer 2-5μm.

Glass ionomer adhesives

- Fuji bond LC, an adhesive material based on resin modified glass ionomer technology.
- Mechanism of adhesion – combined micro-mechanical and chemical interaction with the dental substrate.
- A short polyalkenoic acid pretreatment cleans the tooth surface, removes the smear layer, and exposes collagen fibrils to a depth of about 0.5µm.
- Resin interdiffuses with the establishment of a micromechanical bond.

Glass ionomer adhesives

- The polyalkenoic acid pretreatment is much less severe than an traditional phosphoric acid treatment in that exposed collagen fibrils are not completely denuded of hydroxyapatite.
- Chemical bonding is obtained by ionic interaction of the carboxyl groups of polyalkenoic acid with calcium of hydroxyapatite that remained attached to the collagen fibrils.

- AL-Helal AS et.al investigated the effect of smear layer on root demineralization adjacent to resin modified glass ionomer.
- 4 cavity surface treatments prior to the placement of RMGI: No treatment, polyacrylic acid (PAA), phosphoric acid , and Scotchbond Multi-Purpose adhesive (SMP) as a control. Specimens were aged for two weeks in synthetic saliva, thermocycled, and subjected to an artificial caries challenge (pH 4.4).
- Concluded that removal of the smear layer with phosphoric acid provides significantly enhanced resistance to secondary root caries formation adjacent to RMGI restorations.

AL-Helal AS, Armstrong SR, Xie XJ, Wefel JS. Effect of smear layer on root demineralization adjacent to resin-modified glass ionomer. *J Dent Res* 2003;82(2):146-50.

- Mahdan MH et al (2013) evaluated the combined effect of smear layer characteristics with hydrostatic pulpal pressure (PP) on bond strength and nanoleakage expression of HEMA-free and containing self-etch adhesives.
- Flat dentine surfaces were obtained from extracted human molars. Smear layers were created by grinding with #180 or #600-SiC paper.
- Three HEMA-free adhesives (Xeno V, G Bond Plus, Beautibond Multi) and two HEMA-containing adhesives (Bond Force, Tri-S Bond) were applied to the dentine surfaces under hydrostatic PP.

Mahdan MH, Nakajima M, Foxton RM, Tagami J. Combined effect of smear layer characteristics and hydrostatic pulpal pressure on dentine bond strength of HEMA-free and HEMA-containing adhesives. J Dent 2013;41(10):861-71.

- Dentine bond strengths were determined using the microtensile bond test (μTBS).
- They concluded that the combined effect of coarse smear layer preparation with hydrostatic PP significantly reduced the μTBS of HEMA-free adhesives, while in HEMA-containing adhesives, these effects were not obvious.
- Smear layer characteristics and hydrostatic PP would additively compromise dentine bonding of self-etch adhesives, especially HEMA-free adhesives.

Mahdan MH, Nakajima M, Foxton RM, Tagami J. Combined effect of smear layer characteristics and hydrostatic pulpal pressure on dentine bond strength of HEMA-free and HEMA-containing adhesives. J Dent 2013;41(10):861-71.

- Suyama Y et al (2013) evaluated the effect of smear layer interposition on the bonding effectiveness of self-etching adhesives with different etching potential.
- Bur cut dentin specimens were obtained from 25 human molars after preparation of the dentin surface with a medium-grit diamond bur (bur cut).
- An additional 25 molars were fractured at the midcoronal dentin to create a smear layer free surface (smear free dentin).

Suyama Y, Lührs AK, De Munck J, Mine A, Poitevin A, Yamada T, Van Meerbeek B, Cardoso MV. Potential smear layer interference with bonding of self-etching adhesives to dentin. J Adhes Dent 2013;15(4):317-24.

The prepared teeth were assigned to 5 groups, according to the adhesive to be applied:

- A strong one-step self-etching adhesive (Adper Prompt L-Pop, pH = 0.8);
- Two ultra-mild one-step self-etching adhesives (Clearfil S^3 Bond, pH = 2.7, Adper Easy Bond, pH = 2.7) as the self-etching control,
- A mild two-step self-etching adhesive (Clearfil SE Bond, pH of primer = 1.9); and as the etch-and-rinse control, three-step etch-and-rinse adhesive (Optibond FL).

Suyama Y, Lührs AK, De Munck J, Mine A, Poitevin A, Yamada T, Van Meerbeek B, Cardoso MV. Potential smear layer interference with bonding of self-etching adhesives to dentin. J Adhes Dent 2013;15(4):317-24.

- After composite buildups were made, all specimens were stored in distilled water (24 h/37°C) prior to microtensile bond strength testing (μTBS).
- They concluded that the smear debris interferes with the interaction of mild and ultra-mild self-etching adhesives with dentin.

Suyama Y, Lührs AK, De Munck J, Mine A, Poitevin A, Yamada T, Van Meerbeek B, Cardoso MV. Potential smear layer interference with bonding of self-etching adhesives to dentin. J Adhes Dent 2013;15(4):317-24.

- Oliveira et al determined the effect of dentin smear layers created by various abrasives on the adhesion of a self-etching primer (SE) and total-etch (SB) bonding systems.
- Polished human dentin disks were abraded with 0.05 µm alumina slurry, 240, 320 or 600-grit abrasive papers, # 245 carbide, # 250.9 F diamond or # 250.9 C diamond burs.
- Shear bond strength (SBS) was evaluated, after bonding with SE or SB and with a restorative composite.

Oliveira S , Megan K, Joan FH. The influence of the dentin smear layer on adhesion: a self-etching primer vs. a total-etch system.Dent Mater 2003;19(8):758-767.

- Self-etching primer yielded higher SBS than total-etch group.
- The higher SBS and thin smear layer of the carbide bur group, suggests its use when self-etching materials are used in vivo.
- Overall, the 320-grit abrasive paper surface finish yielded results closer to that of the carbide bur and its use is recommended in vitro as a clinical simulator when using the SE material.

Oliveira S , Megan K, Joan FH. The influence of the dentin smear layer on adhesion: a self-etching primer vs. a total-etch system.Dent Mater 2003;19(8):758-767.

MANAGEMENT OF THE SMEAR LAYER

Smear layer can be treated by three means:

- Chemical
- Thermal
- Mechanical

MANAGEMENT OF THE SMEAR LAYER

Chemical conditioning

- Both acids and chelators, which rely on removing the smear layer, are used as chemical conditioners.
- A) Acid conditioners
- Earlier, acid treatment was only employed on enamel but when used on dentin, their use suffered a lot of resistance because of the fear of pulpal damage.

MANAGEMENT OF THE SMEAR LAYER

- Since Fusayama's pioneering research on total etching with 37% phosphoric acid, the protocol for simultaneous etching on enamel and dentin is being widely accepted.
- Acid conditioners are employed with the objective of not only removing the smear layer but also simultaneously demineralizing superficial dentin of 3-7µm to expose a microporous collagen scaffold into which the resin will penetrate.

MANAGEMENT OF THE SMEAR LAYER

- At the tubule orifices, peritubular dentin is often completely dissolved to form, a funnel shaped structure and expose collagen fibrils which are additional retentive sites at the tubule wall.
- After conditioning, maintenance of a moist dentin surface is recommended, to prevent collapse of unsupported collagen and promote wetting and infiltration of resin.

MANAGEMENT OF THE SMEAR LAYER

- Several acids are used for the purpose of conditioning.
- These include phosphoric acid, maleic acid, citric acid, nitric acid, oxalic acid, pyruvic acid, and hydrochloric acid.
- Phosphoric acid in gel / solution, in a concentration ranging from 30-37% is the most popular agent.
- It denatures the peptides and degree of denaturation depends on the phosphoric acid concentration and time of exposure.

MANAGEMENT OF THE SMEAR LAYER

- Nitric acid is stronger acid than phosphoric acid.
- This is probably because the dentin bonding agents e.g. Tenure (Denmat Corp.), Mirage bond that uses nitric acid conditioners are highly adhesive and provide good dentinal seal.

MANAGEMENT OF THE SMEAR LAYER

- Pure 2.5% nitric acid for 10 seconds is useful for removal of smear layer.
- The combination of 10% citric acid and 3% ferric chloride has been used as smear layer removal and etchant.
- This combination was found to be particularly effective for methacrylate based adhesive containing 4- Methacryloxyethyl trimellitate anhydride (4-META).

MANAGEMENT OF THE SMEAR LAYER

- The ferric ions appear to be necessary, since citric acid alone yield poor results with this system.
- Another combination etchant is 10% citric acid with 20% calcium chloride. (e.g. Clearfil liner bond, Kurraray).
- This combination also results in improved bond strength.

MANAGEMENT OF THE SMEAR LAYER

- Polyacrylic acid solution can also dissolve the smear layer, partially leaving the clumps of debris in the tubule or superficially dissolving away the top part of the smear layer.
- For this reason solutions of polyacrylic acid have been used as cleaning or preparative agents for dentin and enamel before placing glass ionomer cement restoration.

MANAGEMENT OF THE SMEAR LAYER

- In practical clinical application, very clean enamel and dentin surface can be produced by the use of low molecular weight polyacrylic acid for no more than 10-15 seconds followed by thorough rinsing.
- Also 50% solution of citric acid for 1 min can be used for GIC conditioning.

MANAGEMENT OF THE SMEAR LAYER

B) Chelators:

- Contrary to the use of strong acid etchant, chelators are used to remove the smear layer without decalcification or significant physical changes to underlying substrate.
- The best-known chelating conditioner is ethylene diamine tetra acetic acid (EDTA) of pH 7.4.
- It is used in the Gluma (Miles Inc) system.

MANAGEMENT OF THE SMEAR LAYER

- With its use, the smear layer is removed and no significant surface concavity is formed. The smear plugs in the dentinal tubules are not fully removed by 30 seconds application of the conditioner.
- Maleic acid (e.g. Scotchbond-2, 3M) also results in removal of the smear layer but not of the smear plug.
- Although it is quite acidic, it does not appear to decalcify deeply, and the hybrid layer is comparatively thin.

MANAGEMENT OF THE SMEAR LAYER

Thermal conditioning

- The recent trend is to use lasers in conditioning of dentin.
- These may serve as a potential alternative to acids for conditioning of dentin.
- It is speculated that lasers cause recrystallization of dentin resulting in a fungi form appearance that contributes to increased micro-retention or possible chemical adhesion of a restorative material to the tooth structure.

MANAGEMENT OF THE SMEAR LAYER

- Further, they remove the organic elements leaving behind an apatite substance.
- The carbonized black spot that results after lasing is easily washed off with water.
- Studies have confirmed increased bond strengths with lased dentin compared to those with unlased dentin.

- Jhingan P et al (2015) compared and evaluated shear bond strength of self-etching adhesives bonded to cavities prepared by diamond bur or Er,Cr:YSGG laser and the effect of prior acid etching on shear bond strength.
- Ninety six caries free human premolars were selected and divided into 2 groups depending on mode of cavity preparation (48 teeth each).
- Cavities were prepared with Er,Cr:YSGG laser in group 1 and diamond burs in an air turbine handpiece in group 2.

Jhingan P, Sachdev V, Sandhu M, Sharma K. **Shear Bond Strength of Self-etching Adhesives to Cavities Prepared by Diamond Bur or Er,Cr:YSGG Laser and Effect of Prior Acid Etching.** J Adhes Dent. 2015;17(6):505-12.

- Groups 1 and 2 were further subdivided into three subgroups of 8 teeth each, which were bonded with sixth or seventh generation adhesives with or without prior acid etching, followed by restoration of all samples with APX Flow.
- The shear bond strength of adhesives in cavities prepared by Er,Cr:YSGG laser was significantly higher than in diamond bur prepared cavities.
- Seventh-generation adhesives yielded higher shear bond strength than did sixth-generation adhesives. Prior acid etching decreased the shear bond strength of self-etching adhesives.

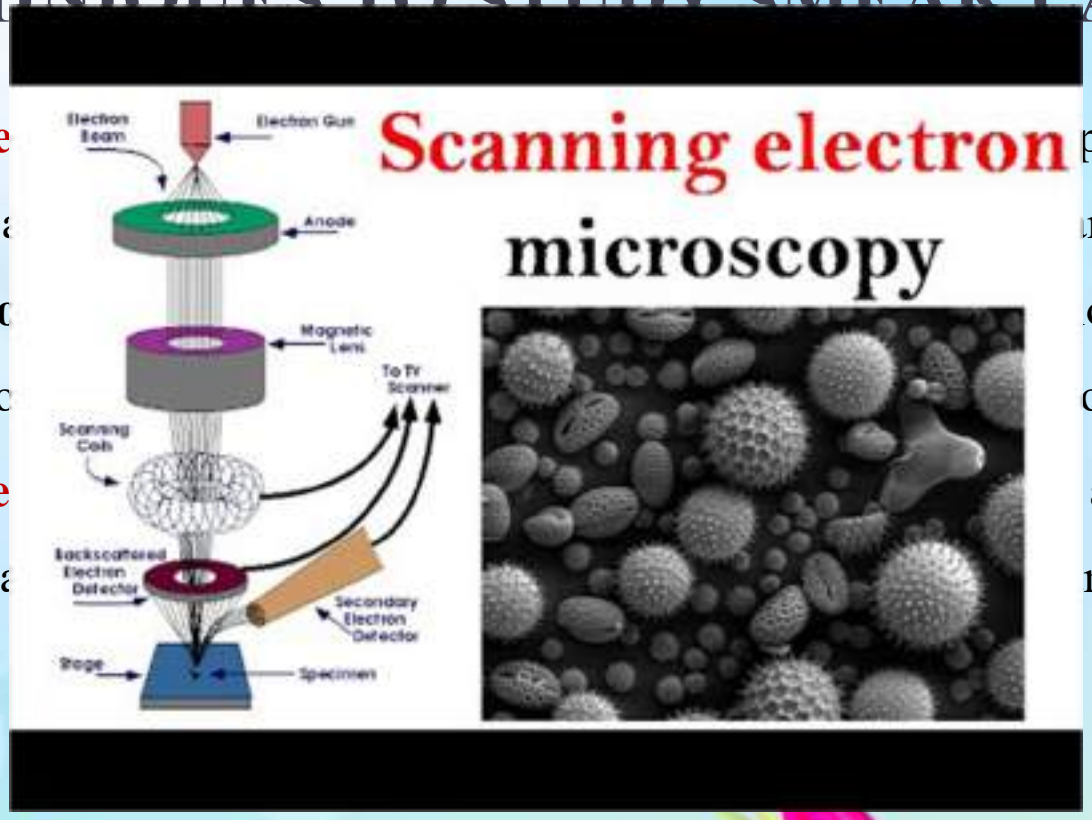
TECHNIQUES TO STUDY SMEAR LAYER

- Sc nning electron micrography

- Transmission electron microscopy - Transmis

TECHNIQUES TO STUDY SMEAR LAYER

- **Scanning e** pe that produces images of a m of **electrons**. The **electro** ous signals that contain infc of the sample.
- **Scanning e** a finely focused (<10 nm dia m.



TECHNIQUES TO STUDY SMEAR LAYER

- **Transmissi**
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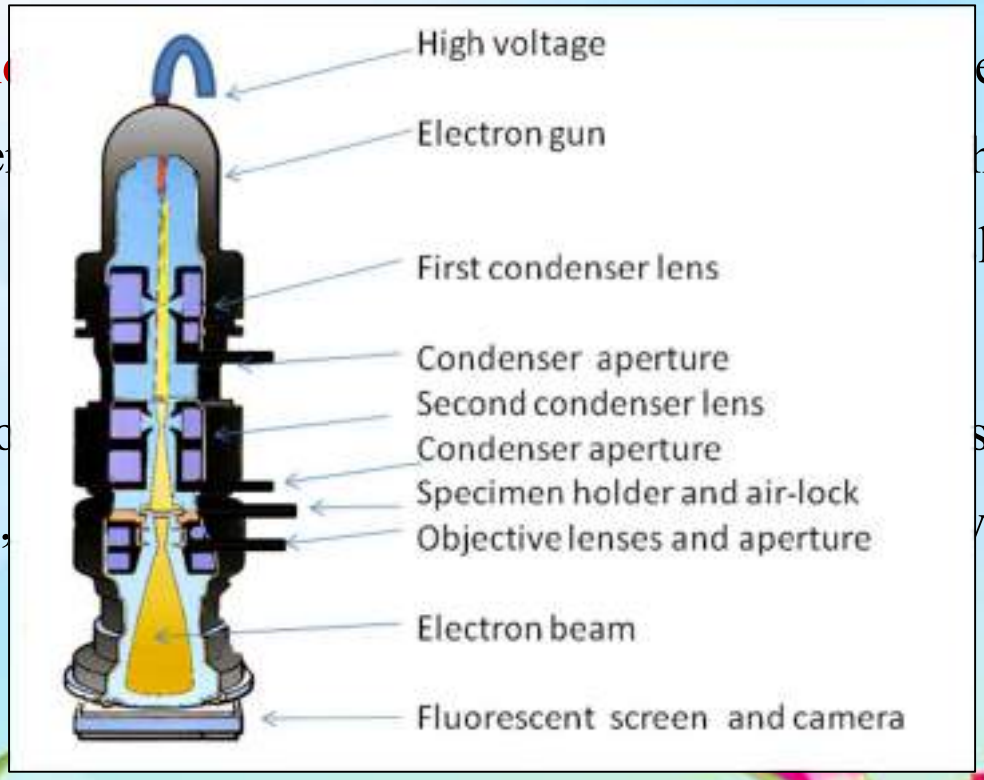
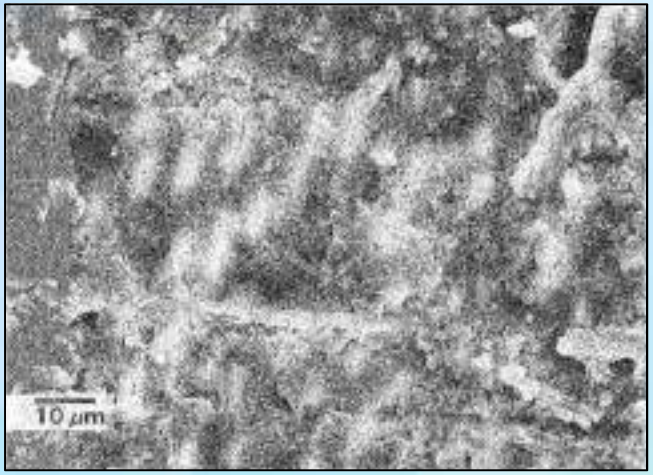
  hieved with a light microscope
  horter than that of a photon.
- It also pro
  scanning electron microscope,
  the surface of a sample.



TECHNIQUES TO STUDY SMEAR LAYER

SEM IMAGE



TEM IMAGE

The smear dilemma

- The question of keeping or removing the smear layer remains controversial.
- Some investigations have focussed on its retention, while others have considered to remove because of its negative effects.
- Microleakage is increased if the smear layer remains, whereas dentin permeability is increased if the smear layer is removed.

The smear dilemma

- Another important consequence of etching and the removal of smear plugs and peritubular dentin at the surface is that the area of wet tubules may increase from 10-25% of the total.
- This moisture does not favor adhesive or mechanical bonding dentin.

The smear dilemma

- The smear layer is far more tenacious than one would expect. **Brannstrom & Johnson (1974)** found that common cleansing procedures such as peroxide followed by 95% alcohol, or other solvents, did not remove the superficial smear layer.
- They found that a nondemineralizing, microbicidal fluoride solution gave a good cleaning effect without opening/enlarging the dentinal tubules.

The smear dilemma

- Various acids (50% citric acid, 50% phosphoric acid) and EDTA were capable of removing the smear layer but, unfortunately, they also removed the smear plugs and peritubular dentin.
- Several investigations were performed to find a suitable cleanser that would retain the smear plugs and remove only the superficial smear layer.
- **Brannstrom** has formulated several commercially available products (Tubulicid Blue Label, Tubulicid Red Label) for this purpose.

The smear dilemma

- A detergent should remove the superficial smear layer, so that an antiseptic component in the cleanser can reach and kill, any bacteria present in the smear plugs.
- It was found that a combination of detergent and 0.2% EDTA, including benzalkonium chloride as an antibacterial component (Tubulicid Blue Label-same as Red Label but without sodium fluoride), has the ability to remove most smear layers without opening tubule apertures or removing peritubular dentin.

The smear dilemma

- It has good antibacterial effect and is non-irritant to the pulp.
- Moreover, it was found that EDTA potentiates the antibacterial action of benzalkonium chloride.
- The solution should be applied for 1 min with an initial and final scrubbing for 5 sec.
- One acceptable solution contained a surfactant combined with 0.2% EDTA and benzalkonium chloride to which 1% sodium fluoride was added (Tubulicid, Red Label).

The smear dilemma

- However, **Brannstrom's (1982)** concept of removing most of the smear layer over the tubules without removing the smear plugs n the tubules is an ideal that is difficult to achieve clinically because of the complex geometry of many cavities and the difficulty of obtaining adequate access.

- **Hamama HH et.al** performed a meta-analysis to critically analyze the effects of dentin surface pretreatment with deproteinizing agents on the bonding of self-etch adhesives to dentin.
- The results of the meta-analysis revealed that the average microtensile bond strength values to dentin pre-treated with deproteinizing agents (15.71 MPa) was significantly lower than those of the non-treated control group (20.94 MPa).
- Dentin surface pretreatment with deproteinizing agents does not enhance the bonding of SE adhesives to dentin. The HOCl deproteinizing agent exhibited minimal adverse effects on bonding to dentin in comparison with NaOCl solutions.

Hamama HHH, Alshaikh KH, Mahmoud SH. **Effect of smear layer deproteinization on bonding of self-etch adhesives to dentin: a systematic review and meta-analysis.** Restor Dent Endod 2018 ;43(2):e1.

CONCLUSION

- The smear layer occupies a strategic position in restorative dentistry. It exists at the interface of most restorative materials and the dentin matrix.
- Understanding better about treating the smear layer will provide increased benefits through improved restorative therapy.

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Thank
You