Dr. Mohammed Ayad

Operative Dentistry

Lecture (2)

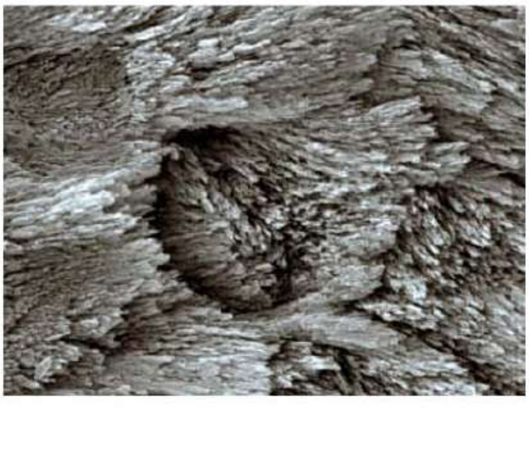
Biologic Considerations of Enamel and their Clinical Significance in Operative Dentistry

Histological View

Enamel is formed by ameloblast cells. Enamel provides a hard, durable shape for the functions of teeth and a protective cap for the vital tissues of dentin and pulp.

Enamel is incapable of repairing itself once destroyed because the ameloblast cell degenerates after formation of enamel rod. The final act of ameloblast cell is secretion of a membrane covering the end of enamel rod. This layer is referred to as Nasmyth membrane or the primary enamel cuticle, which covers the newly erupted tooth and is worn away by mastication and cleaning. The membrane is replaced by an organic deposit called a pellicle, which is a precipitate of salivary proteins. Microorganisms may invade the pellicle to form bacterial plaque, a potential precursor to dental disease.

Enamel Structure



Structurally enamel is composed of millions of enamel rods or prisms. The rods are densely packed and have a wavy course and each extends from the DEJ to the external surface of the tooth.

The structural components of enamel prisms are millions of small elongated apatite crystal which are tightly packed in a distinct pattern of orientation that gives strength and structural identity to the enamel prisms. An organic matrix or prism sheath surrounds individual crystal. The spacing and orientation of the crystals and the amount of organic matrix make the enamel rod boundary and the central core differentially soluble when exposed for a short time to weak acids.

كسرك لقارورة العطر يجعلك تشم الرائحة بقوة ... لكن لآخر مرة .

The acid- treated enamel surface has an irregular and pitted surface with numerous microscopic undercuts, the etched enamel has a higher surface energy, so resin monomer flows into and adheres to the etched depressions to polymerize and form retentive resin tags. Because there are (30,000) to (40,000) enamel rods/ mm^2 and acid etch penetration increases the bondable surface area to (10) to (20) folds, micromechanical bonding of resin restorative materials to E. is significant.

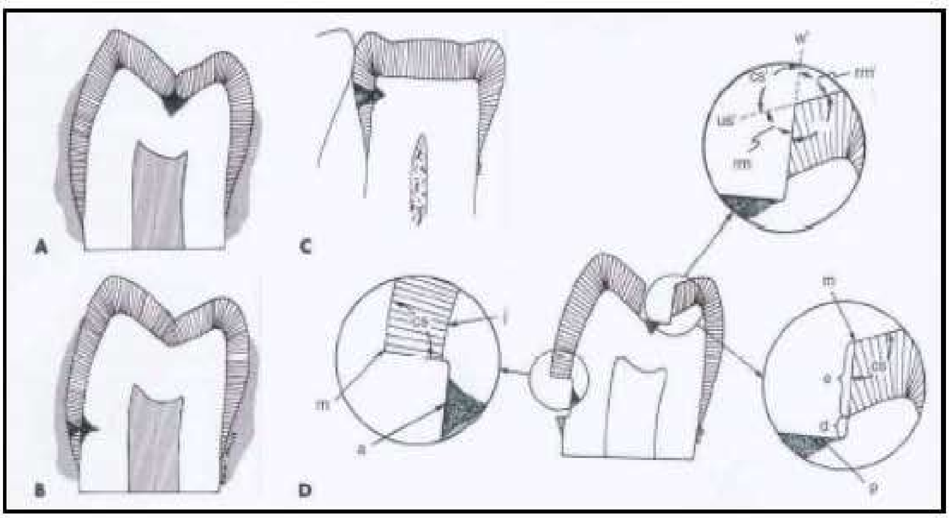
Acid-etch modification of enamel for restoration retention provides a conservative, reliable, alternative to traditional methods of tooth preparation and restorations (retentive grooves, pins, extension for prevention...).

Starting at 1mm from the CEJ, the rods on the vertical surfaces run occlusally or incisally at approximately a 60 degrees inclination and progressively incline approaching the marginal ridges and cusp tips, where the rods are parallel to the long axis of the crown. The rods beneath the occlusal fissures are also parallel to the log axis, but rods on each side of the fissure vary up to 20 degrees from the long axis.

Enamel is hard and durable, but the rod sheaths, where the crystals of the interrod enamel abut three-fourths of each enamel rod cylinder, form natural cleavage lines through which longitudinal fracture may occur.

Chipping of enamel rods at the cavo-surface margin of restored cavity creates a gap defect, leakage of bacteria and their products that may lead to secondary caries. Therefore, a basic principle of cavity wall preparation is to cut enamel parallel the direction of enamel rods or with beveling and avoid undercutting them.

In the cervical region of permanent teeth enamel rods are oriented outward in a slightly apical direction, therefore a perpendicular cut to the external surface of occlusal walls of preparation on axial surfaces compromised enamel, so an obtuse enamel cavo-surface angle is recommended to closely parallel the rod direction and preserve the integrity of enamel margin.



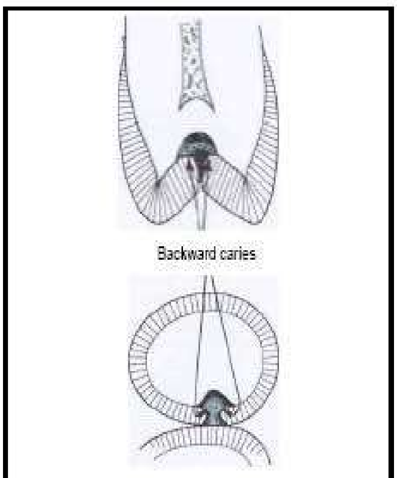


FIG . 6-3 Backward caries extends from DEJ into enamel.

لا تهملوا الكلام الطيب ، فإنه يزهر في القلوب حقولاً من الفرح والبهجة .

Properties of Enamel

1. ***Hardness***

Enamel is the hardest substance of human body. It is as hard as steel with a Knoop Hardness Number (KHN) of 343 (compared to 68 for dentin). However, enamel will wear because of attrition or frictional contact against opposing enamel or harder restorative materials such as porcelain. The normal physiologic contact wear rate for enamel is 15 to 29 µm per year.

2. ***Brittleness***

Enamel is very brittle (the tensile bond strength of enamel rods is low as 1.25 Mpa); thus it requires a supporting base of dentin to withstand the masticatory stress. Enamel rods that fail to possess a dentin base because of caries or improper cavity design are easily fractured away from neighboring rods.

3. ***Permeability***

At maturity, enamel is more than 86% inorganic hydroxyapatite mineral by volume. Enamel also contains a small volume of organic matrix, as well as 4% to 12% water, which is contained in the intercrystalline spaces and in a network of micropores opening to the external surface. The micropores form a dynamic connection between the oral cavity and the pulpal and dentinal tubule fluids.

Various fluids, ions and low molecular weight substance can diffuse through the semipermeable enamel. Therefore, the dynamics of acid demineralization, caries, remineralization, fluoride uptake are not limited to the surface but are active in three dimensions.

4. ***Solubility to acids***

Enamel is soluble when exposed to acid medium, although the dissolution is not uniform. Solubility of enamel increases from the enamel surface to the dentinoenamel junction. When fluorides are present during enamel formation or are topically applied to the enamel surface, the solubility of surface enamel is decreased. Fluoride concentration decreases toward the dentinoenamel junction. Fluoride additions can affect the chemical and physical properties of the apatite mineral and influence the hardness, chemical reactivity, and stability of enamel while preserving the apatite structures. Trace amounts of fluoride stabilize the enamel by lowering acid solubility, by decreasing the rate of demineralization, and by enhancing the rate of remineralization.

5. ***Color***

Enamel is relatively translucent. It has a glossy surface and varies in color from light yellow to grayish white. Therefore, the color of the tooth is primarily a function of the color of underlying dentin, enamel thickness and the amount of the stain in the enamel. The thickness of enamel is greater at the cusps tips

(2.5mm) and incisal edges (2mm) and decreases below deep fissures and become thin cervically at the junction with cementum.

The amount of translucency of enamel is related to the variation in the degree of calcification and homogeneity.

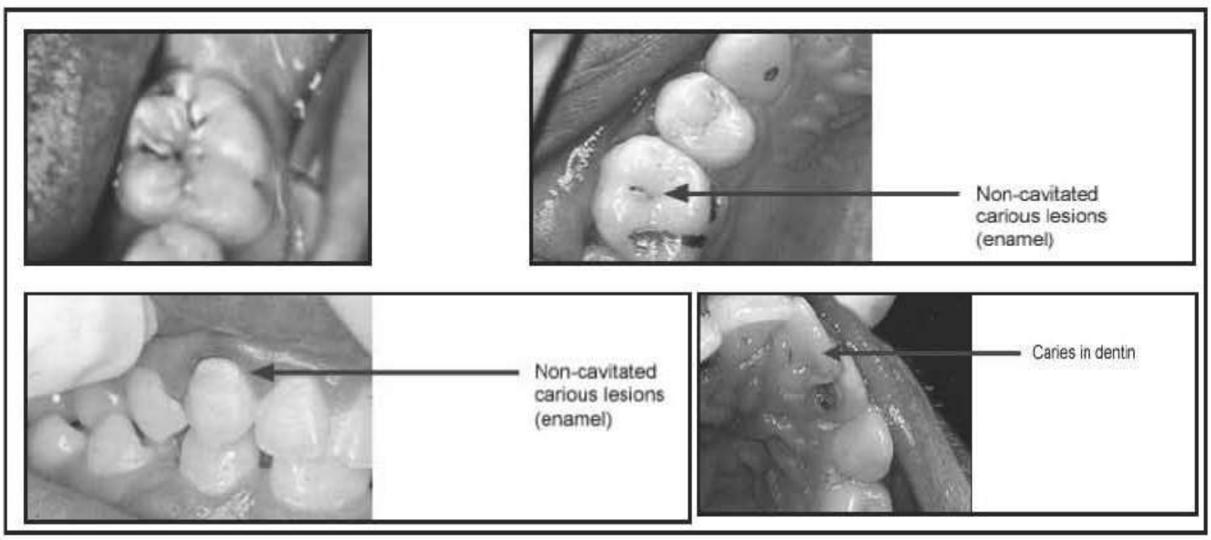
Abnormal conditions of enamel usually result in aberrant color. Enamel becomes temporary whiter within minutes when the tooth is isolated from the moist oral environment by rubber dam or absorbents. Thus, the shade must be determined before isolation and preparation for a tooth - colored restoration. This change in color explained by the temporary loss of loosely bonded (or exchangeable) water.

Clinical Appearance and Diagnosis

The dentist must pay close attention to the surface characteristics of E. for evidence of pathologic or traumatic conditions. Key diagnostic sings include:

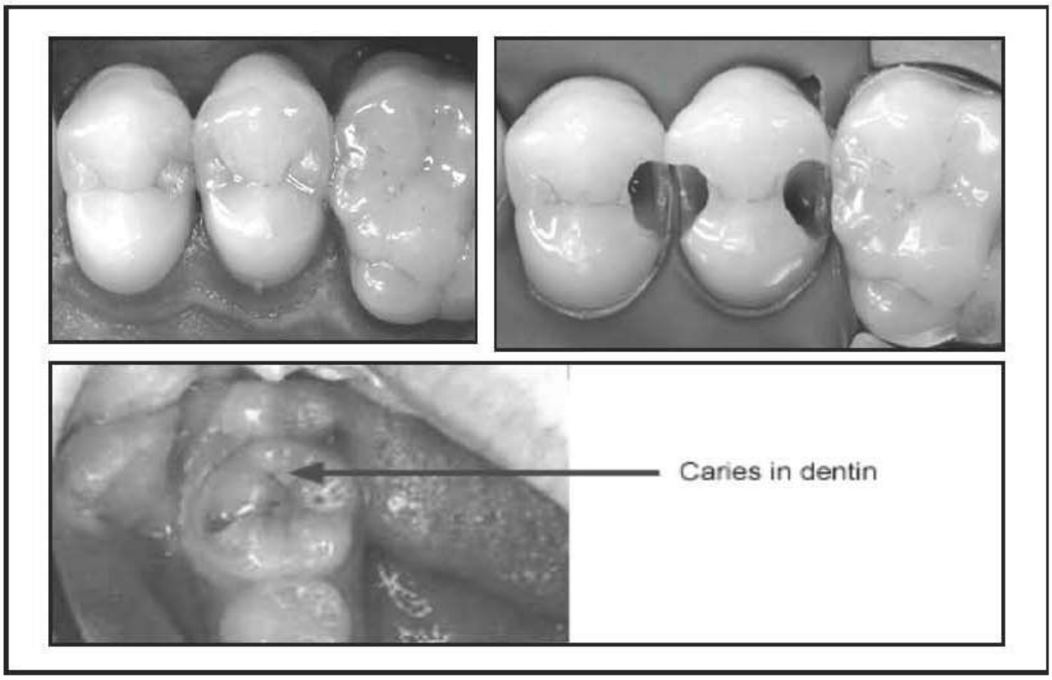
1. Color changes associated with demineralization

Color changes related to enamel demineralization and caries are critical diagnostic observation. Subsurface enamel porosity from carious demineralization is manifested clinically by a milky white opacity called (white spot lesion); when located on smooth surfaces. In later stages of caries, internal demineralization of enamel at the DEJ, subsurface cavitation imparts a blue or gray color to the overlying enamel.



2. Cavitation

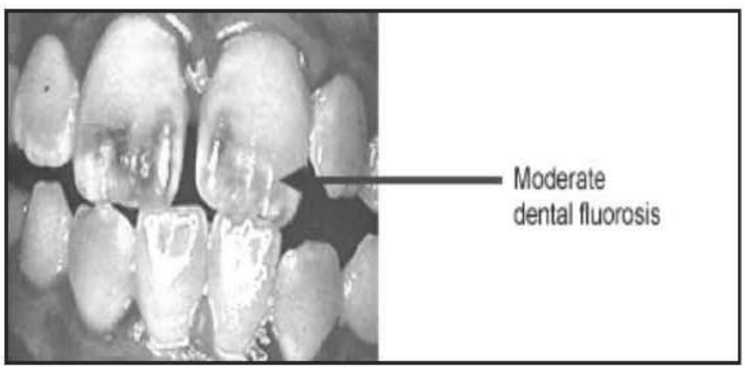
The dentin is affected until enamel breaks away to create a cavity, a restoration must then be placed. If untreated the cavitation expands to compromise the structural strength of the crown and microorganisms infiltrate into deep dentin to affect the vitality of the tooth. When the carious lesion extends gingival to CEJ as in root caries, isolation, access and gingival tissue response complicate the restorative procedure.



3. Wear

Heavy occlusal wear is demonstrated when rounded cuspal contacts are ground to flat facets.

Depending on factors such as bruxism, malocclusion, age and diet; cusps may be completely lost and enamel abraded away so that dentin is exposed. During cavity preparation, the outline form should be designed so that the margins of restorative materials avoid critical high stress areas of occlusal contact.

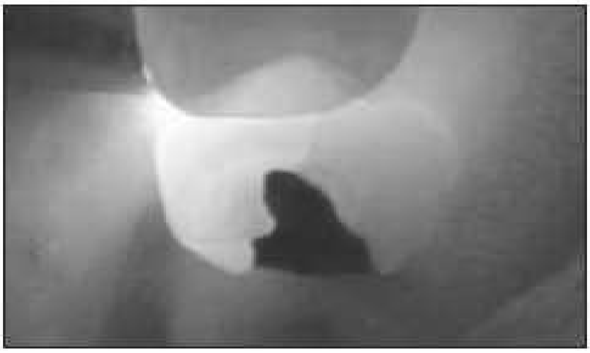


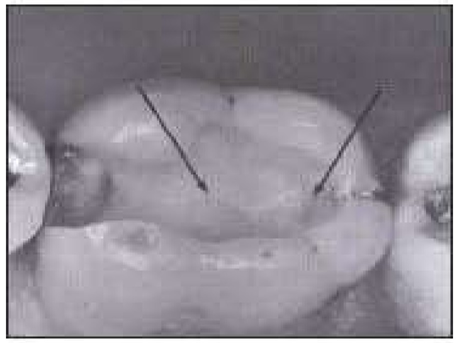
4. Faults and fissures

A deep fissure is formed by incomplete fusion of lobes of cuspal enamel in the developing tooth. The resulting narrow clefts provide protected area for acidogenic bacteria. Pits and fissures defects are eight times more vulnerable to caries than are smooth surfaces. Careful observation of enamel surrounding fissures for evidence of demineralization or cavitations' is necessary to determine the need for restorative intervention.

5. Cracks

Pronounced cracks that extend from developmental grooves across marginal ridges to axial walls or from the margins of large restorations may cause cuspal fracture. When this crack extends through dentin or when the patient has pain when chewing; the tooth requires a restoration that provide complete cuspal coverage.





لا تطمح ان تكون افضل من الاخرين .. اطمح ان تكون افضل من نفسك سابقاً
فـالـعـقـول تصـغـر عندما تنشغل بالاخـريـن ... وتـكـبـر عندما تنشغل بذاتهـا .

Operative Dentistry

Dr. Mohammed Ayad

Lecture (3)

Patient Assessment, Diagnosis and Treatment Planning (Part I)

Pretreatment considerations consisting of patient assessment, examination and diagnosis, and treatment planning are the foundation of sound dental care.

Excellence in dental care is achieved through the dentist's ability to assess the patient, determine his needs, and design an appropriate plan of treatment.

Infection Control

Before the examination and diagnosis, attention is given to infection control. Before, during and after any patient visit, appropriate infection control measures must be instituted. Barrier protection of personnel using masks, protective eyewear, gloves and gowns is now a standard requirement for dental procedures.

Patient Assessment

Medical History

The medical systemic care phase includes aspects of treatment that affect the patient systemic health. Comprehensive medical history that helps to identify conditions that could alter, complicate or contraindicate dental procedures. For example, the dentist may identify

1. Contagious diseases that require special precautions, procedures, or referral
2. Allergies or medications that may contraindicate the use of certain drugs;
3. Systemic diseases and cardiac abnormalities that demand less strenuous procedures or prophylactic antibiotic coverage; and
4. Physiologic changes associated with aging that may alter clinical presentation and influence treatment.

Chief Complaint

It is generally the first information obtained. Chief complaints are symptoms or problems expressed by the patient in his own words relating to the condition that prompted the patient to seek treatment. The patient should be encouraged and guided to discuss all aspects of the current problem, including onset, duration, symptoms, and related factors.

By this discussion, the dentist accomplishes many important goals:

1. The patient feels that his problem have been recognized and the doctor-patient relationship begins positively.
2. This information is vital to establish the need for specific diagnostic tests and to determine the cause and treatment of the complaint.
3. By writing C.C (chief complaint) the dentist is assured that it will not be omitted from the problem list.

Dental History

A brief history of past dental treatment can provide useful information about patient's tolerance for dental treatment. Questions about previous episodes of fractured or lost restorations, trauma, infection, sensitivity and pain can give information that will alter the dentist to possible problems and guide him to clinical and radiographic examination. Patients may not volunteer this information; hence specific questions regarding thermal sensitivity, discomfort during chewing, gingival bleeding and pain are warranted. When there is a history of symptoms indicative of pulpal damage or incomplete tooth fracture, specific diagnosis tests should be performed during the examination.

Clinical Examination

Clinical examination is the "hands-on" process of observing both normal and abnormal conditions. Diagnosis is a determination and judgment of variations from normal.

The intraoral assessments involve an examination of the periodontium, dentition and occlusion.

The clinical examination is performed systematically in a clean, dry, well-illuminated mouth. Proper instruments including a mirror, explorer, and periodontal probe are required.

An accurate examination can occur only when the teeth are clean and dry. This may require initial scaling, flossing, and a toothbrushing prophylaxis before clinical examination of the teeth.

Elements of the clinical examination include:

1. EVALUATION OF THE DENTITION

A. Assessment of caries risk and plaque: the determination of baseline caries risk and plaque levels at the time of initial examination provides a basis for communication with the patient and the dentist, and it is important information in establishing a prognosis for restorative care. The patient can be given instructions for good oral hygiene. Once plaque assessment completed an examination of other areas can be accomplished

B. Detection of caries lesions:

- Pit and fissure caries lesions: it may begin in small enamel defects that lie near DEJ, so it is difficult to detect early on radiograph (it must be extensive to be detected radiographically).

Tactile examination with firm application of sharp explorer into fissure and a sticky sensation felt on removal of the explorer has been the classic sign of pit and fissure caries. Clinical studies have shown this method to be unreliable, producing many false-positive and false-negative diagnosis, in addition an explorer can cause cavitation in a demineralized pit and fissure, preventing the possibility of remineralization.

Visual observation with magnification of a clean dry tooth has been found to be reliable non destructive method. Pit and fissure lesions appear as a gray or gray-yellow opaque area that show through the enamel.

Fiberoptic transillumination may be helpful in visualizing pit and fissure lesion.

A variety of new technologies are being evaluated for detection of caries lesions like air abrasion and laser.

- Smooth-surface caries lesions: proximal caries are the most difficult to detect clinically, it is inaccessible to both visual and tactile examination, proximal lesions usually detected by radiograph in posterior teeth wile in anterior teeth may be diagnosed radiographically or with visual examination; using transillumination. Smooth caries on buccal and lingual surface can be easily detected by visual and tactile examination.

C. Assessment of the pulp: each tooth that has extensive restoration and teeth with pulps of questionable vitality; should be tested.

1. **The application of cold and hot** is a valuable method of vitality testing. A cotton pellet saturated with an aerosol refrigerant spray such as (tetrafluoroethane), is placed on the tooth to determine vitality or a pencil of ice made by freezing water inside a sterilized anaesthetic cartridge. Hot application is also helpful by applying a heated piece of gutta-percha on the tooth surface.
2. **Electric pulp tester** another method of vitality test. However this test has limitations, it cannot be used in a wet field or on teeth with metallic restorations unless measures are taken to insulate adjacent teeth. Also the method does not reflect the health of the pulp or its prognosis.
3. **A test cavity:** used when previous thermal and electric pulp tester failed to provide a clear picture of pulp vitality and a restoration is indicated. So the preparation initiated without using anesthetic. If pain or sensitivity is elicited when dentin is cut with a bur, pulpal vitality is confirmed.

Other tests that should be conducted during examination are

<u>Percussion test</u>: This test is performed by gently tapping the occlusal **or** incisal surfaces of the suspected tooth and adjacent teeth with the end of the handle of a mouth mirror to determine the presence of tenderness. Pain on percussion suggests possible injury to the periodontal membrane from pulpal or periodontal inflammation. Care must be taken when interpreting a positive response on maxillary teeth because teeth in close proximity to maxillary sinuses also may exhibit pain on percussion when the patient has maxillary sinusitis.

<u>Palpation:</u> This test is performed by rubbing the index finger along the facial and lingual mucosa overlying the apical region of the tooth, an alveolar abscess in an advanced stage or other periapical pathosis may cause tenderness to palpation.

Dr. Mohammed Ayad

Operative Dentistry

Lecture (1)

Biologic Considerations of Dentin and their Clinical Significance in Operative Dentistry

Dentin is a mineralized connective tissue that is covered by enamel in the crown and cementum in the root, as well as enclosing the innermost pulp.

Mature dentin is a crystalline material that is less hard than enamel but slightly harder than bone. Mature dentin is 45% - 50% inorganic or mineralized material, 30% organic material, and 25% water. This crystalline formation of mature dentin mainly consists of calcium hydroxyapatite with the chemical formula of $Ca_{10}(PO_4)_6(OH)_2$. The calcium hydroxyapatite found in dentin is similar to that found in a higher percentage in enamel and in lower percentages in both cementum and bone tissue, such as the alveolar process. In addition, the crystals in dentin are platelike in shape and 30% smaller in size than those in enamel. Small amounts of other minerals, such as carbonate and fluoride, are also present.

Functions

1. Dentin forms the bulk of the tooth (both in the crown and root).
2. The coronal dentin (crown) provides color for the overlying enamel.
   Because of the translucency of overlying enamel, the dentin of the tooth gives the white enamel crown its underlying yellow hue, which is a deeper tone in permanent teeth. When the pulp undergoes infection or even dies, there is discoloration of the dentin, which causes darkening of the clinical crown.
3. Dentin also has great tensile strength, providing an elastic basis for the more brittle enamel.
4. Tooth strength and rigidity are provided by intact dentinal substrate. Resistance of tooth to fracture is significantly lowered with increasing depth and width of cavity preparation. Therefore, a conservative initial approach that combines localized removal of carious tooth structure, placement of a bonded restoration, and placement of sealant is recommended. If large preparations are required, the dentist should consider placement of onlay or crown.
5. Protective encasement for the pulp.

As a vital tissue without vascular supply or innervation, it is nevertheless able to respond to thermal, chemical or tactile external stimuli.

Properties of Dentin

1. ***Hardness***
   Hardness of dentin is one-fifth that of enamel. Its hardness at DEJ is 3 times more than near pulp.
   Hardness of dentin also increases with advancing age due to mineralization.
2. ***Strength***
   Tooth strength, rigidity, and integrity rely on an intact substrate. Dentin has a tensile strength of 40MPa and a compressive strength of 266MPa. However, tooth resistance to fracture is compromised with increasing depth and/or width of cavity preparation.
3. ***Elastic modulus***
   Low modulus of elasticity of dentin makes it flexible in nature. This flexibility provides support or cushion to the brittle enamel.
4. ***Permeability***
   Unlike enamel which is semipermeable, dentin is a permeable structure and its permeability is directly related to dentinal tubule diameter and length. The diffusion gradient is also affected by the intratubular cellular, collagenous, and mineral inclusions which can restrict the flow through the tubular channels.

Dentin can be distinguished from enamel (during tooth preparation), by:

1. ***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.
2. ***Reflectance:*** dentin surfaces are more opaque and dull, being less reflective to light than enamel surfaces, which appear shiny.
3. ***Hardness:*** dentin is softer than enamel, sharp explorer tends to catch and hold in dentin.
4. ***Sound:*** when moving an explorer tip over the tooth, enamel surfaces provide a sharper, higher pitched sound than dentin surfaces.

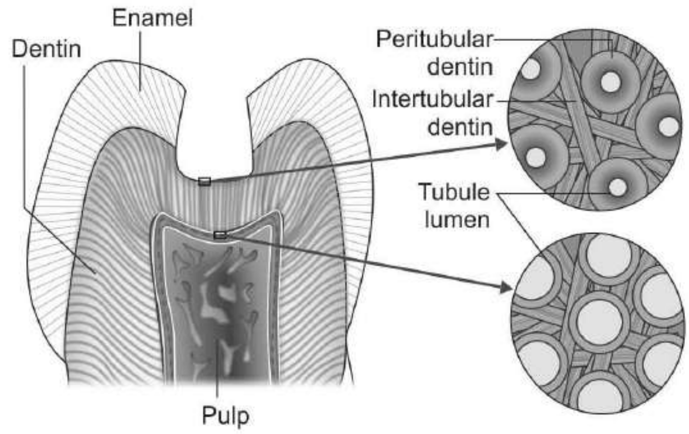
	Enamel	Dentin
Color	Whitish blue or white gray	Yellowish white or slightly darker than enamel
Sound	Sharp, high-pitched sound on moving fine explorer tip	Dull or low-pitched sound on moving fine explorer tip
Hardness	Hardest structure of the tooth	Softer than enamel
Reflectance	More shiny surface and reflective to light than dentin	Dull and reflects less light than enamel

There are two main types of dentin which are:

1. **Intertubular dentin:** the primary structural component of the hydroxyapatite- embedded collagen matrix between tubules.
2. **Peritubular dentin:** the hypermineralized tubular walls.

These component ratios vary according to depth of dentin, age and traumatic history of the tooth.

The dentinal tubules in the *Outer Dentin* which is near the DEJ are relatively far apart and the Intertubular dentin makes up 96% of the surface area. In the *Inner Dentin*, the tubules diameters are larger and the distance between tubule centers is half that of tubules at DEJ. Thus, the intertubular matrix area is only 12% of the surface area, and the permeability of inner dentin is about eight times more permeable than the dentin near DEJ.



Permeability of Dentin

The permeability of dentin is directly related to its protective function. When the external cap of enamel and cementum is lost from the periphery of the dentinal tubules through caries, preparation with burs or abrasion and erosion, the exposed tubules become conduits between the pulp and the external oral environment. Restored teeth are also at risk of toxic seepage through the phenomenon of microleakage between the restorative material and the cavity wall, through capillary action differential thermal expansion, and diffusion, fluids containing various acidic and bacterial products can penetrate the gap between the tooth and restoration and initiate secondary caries of the internal cavity walls. Bacterial substances can continue diffusion through permeable dentinal tubules to reach the pulp, putting the tooth at risk for pulpal inflammation and sensitivity. So restorative techniques with varnishes, liners or dentin bonding resin adhesives are effective to provide reliably sealed margins and sealed dentinal surface.

The remaining dentin thickness is the key determinant of the diffusion of gradient.

Sensitivity of Dentin

Although dentin is sensitive to thermal, tactile and osmotic stimuli across its (3-3.5 mm) thickness, dentin is neither vascularized nor innervated, except for about 20% of tubules that have nerve fibers penetrating inner dentin by few microns. Therefore, odontoblast and its process is the possible stimulus receptor.

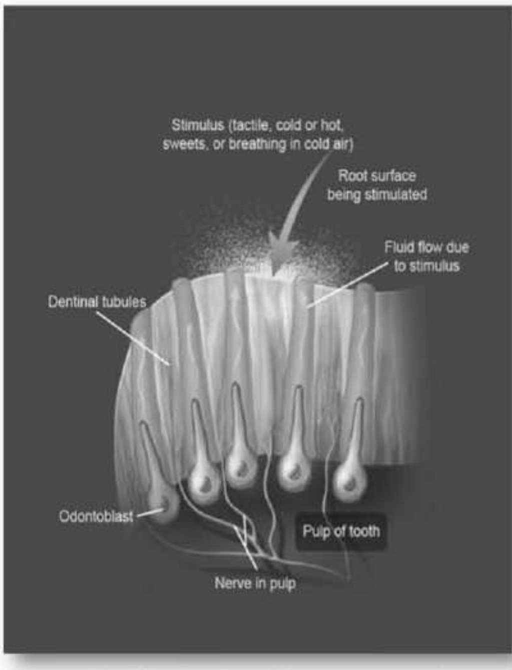
Theories of Pulpal Sensitivity

1. ***Theory of thermal shock***

This states that sensitivity is the result of direct thermal shock to the pulp via temperature changes transferred from the oral cavity through the restorative material, especially when the remaining dentin is thin. Protection from this insult would then be provided by an adequate thickness of an insulating material.

2. ***A hydrodynamic theory***

This theory based on the capillary flow dynamics of the fluid-filled dentinal tubule. In a vital tooth with exposed dentin there is a constant slow movement of fluid outward through the dentinal tubules. The hydrodynamic theory proposed that when a stimulus such as air evaporation, cold or heat (i.e. generated from dental bur) or tactile pressure these stimuli causes the slow fluid movement to become more rapid causing displacement of odonoblast bodies and the nerve endings in the pulp are deformed, a response that is interpreted as pain.



As dentin near the pulp, tubule density and diameter increase also the permeability increase, thus increasing both the volume and flow of fluid. This explains why deeper restorations are associated with more problems of sensitivity.

According to this theory, if the tubules can be occluded, fluid flow is prevented and temperatures do not induce pain. So, the operative factor in reducing sensitivity to thermal changes is by effective sealing of the dentinal tubules rather than placement of an insulating material.

This theory has gained general acceptance in recent years and has changed the direction of restorative procedures away from thermal insulation and toward dentinal sealing. Thus, there is increasing emphasis on the integrity of the interface between restorative material and cavity preparation.

Physiologic and Tertiary Dentin

Physiologic dentin

1. Primary dentin: formed relatively quickly until root formation is completed by odontoblasts.
2. Secondary dentin: this is slowly formed dentin that continues to constrict the dimensions of the pulp chamber. In response to mild occlusal stimulus, secondary dentin is mainly deposited in the pulp horns and on the roof and floor of the pulp chamber so after many decades the chamber

becomes quite narrow occluso-gingivally. The dentist must pay attention for the size and location of the pulp chamber to decide the design of the preparation and placement of retentive features such as pins.

Sclerotic dentin (transparent or peritubular dentin)

Results from aging or mild irritation (such as slow caries) and causes a change in the composition of the primary dentin. The tubular content appears to be replaced by calcified material that obliterates the tubules, progressing from the DEJ pulpaly. These areas are harder, denser, less sensitive and more protective of the pulp against subsequent irritation.

Sclerosis resulting from aging is (physiological dentin sclerosis) and that resulting from mild irritation called (reactive dentine sclerosis).

Reparative dentin (tertiary dentin)

Intense traumatic insult (injury) to the tooth, whether caused by bacterial penetration associated with caries, or heat and trauma from a dental bur, may be severe enough to destroy the supporting odontoblasts in the affected location. Within 3 weeks, fibroblasts or mesenchymal cells of the pulp are converted or differentiated to stimulate the activities of original odontoblast, and form irregularly organized tubules.

The rate of formation and the thickness and organization of reparative dentin depend on the intensity and duration of the stimulus.

The barrier of reparative dentin is superior because there is no continuity between the affected permeable tubules of the regular primary dentin and those within the reparative dentin.

The tooth will be able to compensate for the traumatic or carious loss of peripheral dentin with deposition of new dentin substrate and reduction of pulpal irritation from tubule permeability. Unless the lesion is either arrested or removed and a restoration placed, the diffusion of bacterial toxins reaching the pulp and initiate strong inflammatory response and result in pulpal necrosis.

	Primary	Secondary	Tertiary
Definition	Dentin formed before root completion	Formed after root completion	Formed as a response to any external stimuli such as dental caries, attrition and trauma
Type of cells	Usually formed by primary odontoblasts	Formed by primary odontoblasts	Secondary odontoblasts or undifferentiated mesenchymal cells of pulps
Location	Found in all areas of dentin	It is not uniform, mainly present over roof and floor of pulp chamber	Localized to only area of external stimulus
Orientation of tubules	Regular	Irregular	Atubular
Rate of formation	Rapid	Slow	Rapid between 1.5 and 3.5 μm/day depending on the stimuli
Permeability	More	Less	Least

Operative Dentistry

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Lecture (5)

Enamel and Dentin Bonding (Agents and Techniques)

Definition

The bonding agents (dental adhesives) are resinous materials used to enable the restorative material to bond and adhere to dental hard tooth structures (enamel, dentin, and cementum).

Requirements of Dental Adhesives

1. Provide high bond strength to enamel.
2. Provide bond strength to dentin similar to that to enamel.
3. Show good biocompatibility to dental tissue, including the pulp.
4. Prevent and minimize microleakage at the margins of restorations.
5. Prevent recurrent caries and marginal staining.
6. Easy to use.
7. Possess a good shelf life.
8. Compatible with a wide range of resins.

Indications

1. To aids in bonding composite and even amalgam restorations to tooth structure.
2. To treat dentinal hypersensitivity.
3. For the repair of fractured porcelain, amalgam and resin restorations.
4. For pit and fissure sealants.
5. To lute crowns.
6. To bond orthodontic brackets.

Adhesive System Classification

Adhesives have been classified using several methods: generation (from 4^{th} through 8^{th}), solvent type (water, ethanol, and acetone), mechanism of smear layer removal (etch and rinse "E&R", and self etch "SE"), and number of clinical steps (3-step E&R, 2-step E&R, 2-step SE, and 1-step SE).

Enamel Bonding

Bonding to enamel requires two clinical steps; 1) Acid etching, followed by 2) The application of the adhesive resin to the etched surface.

Dentin Bonding

Bonding to dentin has been proven more difficult and less reliable and predictable than enamel. This is because of morphologic, histologic and compositional differences between them. It requires etching, priming, and bonding.

Problems Encountered During Dentin Bonding

1. Dentin contains more water than does enamel.
2. Hydroxyapatite crystals have a regular pattern in enamel whereas in dentin, hydroxyapatite crystals are randomly arranged in an organic matrix.
3. Presence of smear layer makes wetting of the dentin by the adhesive more difficult.
4. Dentin contains dentinal tubules which contain vital processes of the pulp, odontoblasts. This makes the dentin a sensitive structure.
5. Dentin is a dynamic tissue which shows changes due to aging, caries or operative procedures.
6. Fluid present in dentinal tubules constantly flows outwards which reduces the adhesion of the composite resin.

Components of Dental Adhesives

Dental adhesives consist of three main components: (1) etchant (acidic molecules that alter or remove the smear layer), (2) primer, and (3) bonding resin (adhesive resin).

1. Etchant:

A-In E&R Adhesives: A separate etching step is required using a strong acid (usually 35% to 37% phosphoric acid at a pH of approximately 0.9) to completely etch enamel and dentin, followed by a thorough water rinse.

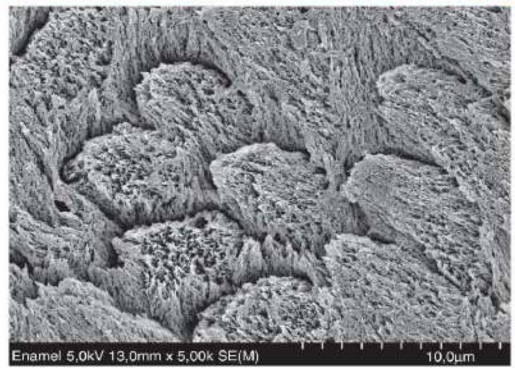
On enamel, it is applied for 15 to 30 seconds and the goals of enamel etching are

1) Cleaning enamel surface from the smear layer.

2) Increasing the enamel surface area available for bonding.

3) Demineralization and partially dissolving the mineral crystallites to create retentive microporosities into which the resinous bonding agent can infiltrate and form retentive resin tags (micromechanical retention). These tags are formed within a 550-µm-thick microporous layer.

4) In addition, acid etching increases the surface energy and lowers the contact angle of resins to enamel.



It has been shown that optimal enamel–resin bonds could be achieved as long as the etched enamel surface was clean and free from any contamination.

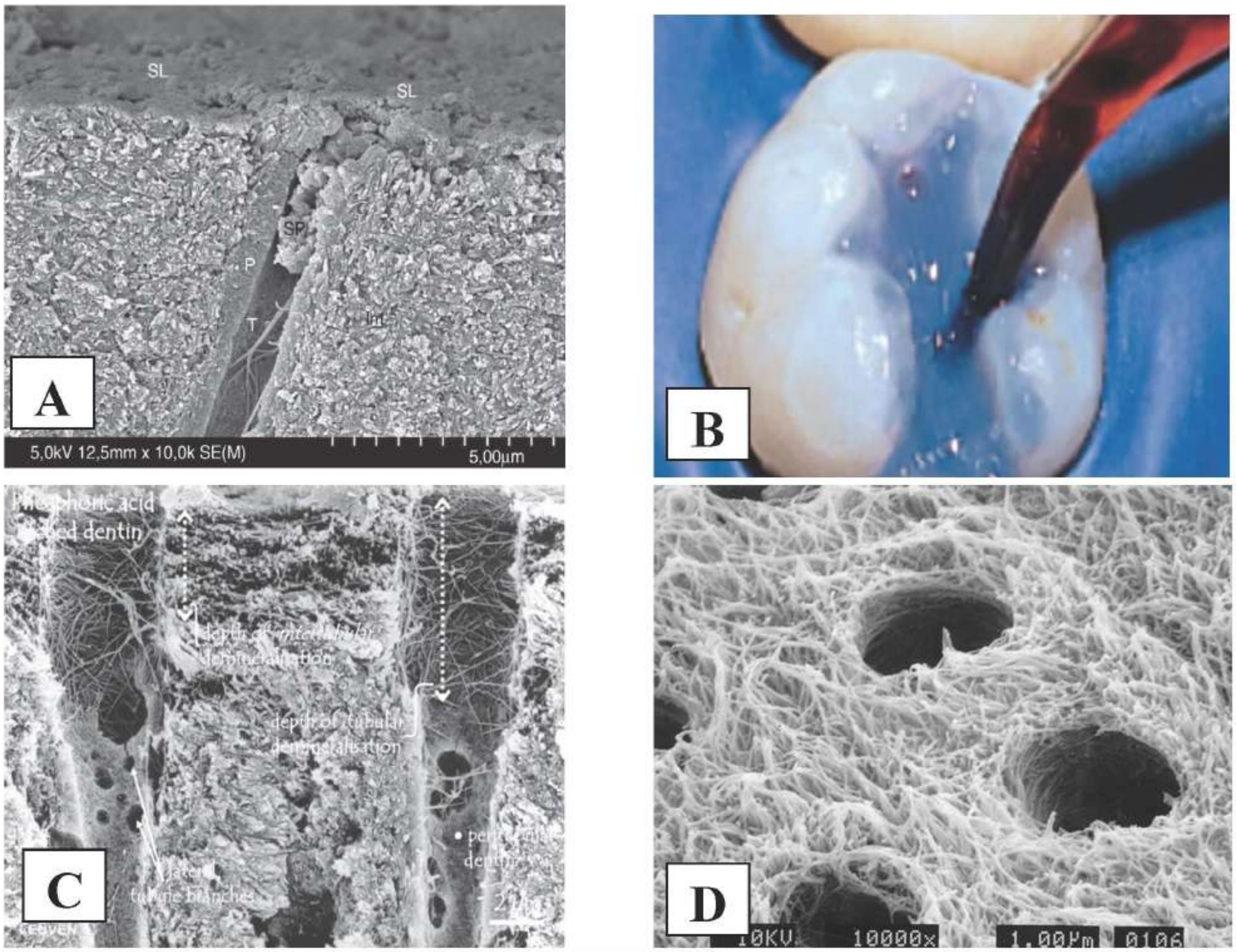
• If phosphoric acid concentration is greater than 50%, then monocalcium phosphate monohydrate will get precipitated.

• If concentration is lower than 30%, dicalcium phosphate monohydrate is precipitated which interferes with adhesion.

• Deciduous teeth require longer time for etching than permanent teeth because of the presence of aprismatic enamel in deciduous teeth.

On dentin, the etchant is applied for not more than 15seconds followed by thorough rinsing with water. The acid 1) removes the smear layer (1-5µm thick amorphous layer comprised of residual organic and inorganic debris formed as a result of mechanical cutting of enamel and dentin), 2) demineralizes the superficial 3-5 µm of the superficial dentin exposing the collagen fibrils of the dentinal matrix, and 3) removes smear plugs (debris occluding the dentinal tubules orifices) and open the dentinal tubules, funneling their orifices. Areas from where minerals are removed are filled with water. This water acts as a plasticizer for collagen, keeping them in an expanded soft state. Thus, spaces for resin infiltration are also preserved.

If the dentin surface is made too dry, there will be collapse of the collagen fibers of demineralized dentin. This results in low bond strength because of ineffective penetration of the adhesive into the dentin.



Dentin Etching. A: prepared cavity showing smear layer SL, B: acid etching, C: demineralized dentin, D: exposed collagen fibrils.

B- In SE Adhesives: No separate step of etching is required since the etching component (either weak acid or acidic monomer) is already included within the primer or adhesive solution. These adhesives render the smear layer permeable to monomers rather than removing it completely. Some self-etching adhesives simultaneously dissolve the smear layer and infiltrate enamel and dentin, using the mineral content of the substrate to buffer the acidic monomers and inhibit their dentin-etching ability with increasing depth.

2. Primer:

The primer is a mixture of monomer molecules possessing both hydrophilic as well as hydrophobic ends which have affinity for the exposed collagen and resin respectively. Solvents are added to reduce the inherent viscosity of co-monomer blends, allowing them to infiltrate wet demineralized dentinal matrices.

Primers are used to increase the diffusion of resin adhesive into moist and demineralized dentin and thus obtaining optimal micromechanical bonding.

After rinsing of the etching agents, the presence of adequate water maintains the full expansion of the demineralized dentinal matrix. It is important to remove excess pooled moisture by air blotting or wiping with a micro-brush or an absorbent paper. Properly moist dentin should exhibit a shiny, hydrated surface. However, excessive air drying of dentinal surfaces removes most of the water from the matrix, causing the collagen fibrils to collapse and shrink resulting in lack of sufficient interfibrillar spaces available for resin penetration. To resolve this undesirable situation, the dentin must be rewetted and primed to re-expand the collapsed matrix.

For optimal penetration of primer into demineralized dentin, it should be applied in multiple coats and it should be gently air sprayed after application to volatilize any remaining solvent before the adhesive resin is applied. Any remnant solvent will be trapped in the polymerized interface and will weaken the adhesive-dentin bond.

NOTE: After priming, do not light cure. The primer function is to pave the way for the resin adhesive.

Examples of primer monomers are:

HEMA (hydroxyethyl methacrylate),

TEGDMA (triethyleneglycol dimethacrylate),

bis-GMA, (Bisphenol glycidyl methacrylate)

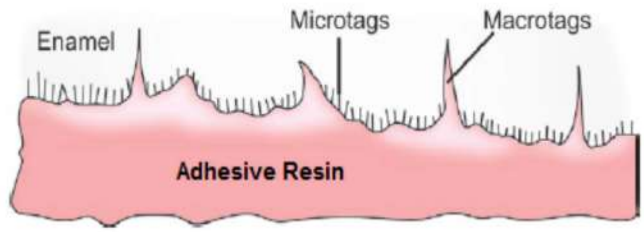
UDMA (urethane dimethacrylate), and

4-META (4-Methacryloxyethyl trimellitate anhydride)

3. Adhesive resin:

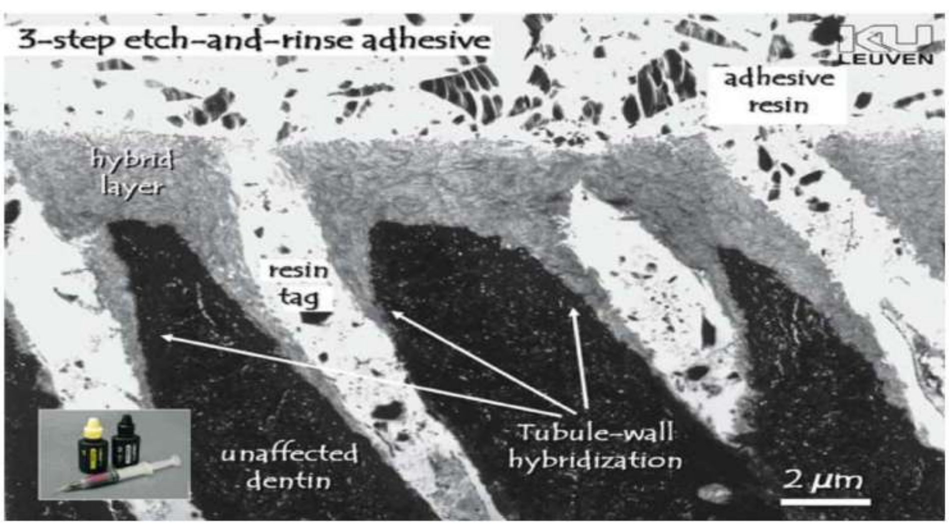
Adhesive resins are hydrophobic solvent-free monomer blends (usually bis-GMA or UDMA with TEGDMA added to lower the viscosity of the bonding agent).

On Enamel: The bonding agents rapidly wet and penetrate the clean, dried, conditioned enamel into the microspaces forming resin tags. The resin tags which form between enamel prisms are known as macrotags. Finer network of numerous small tags is formed across the end of each rod where individual hydroxyapatite crystals were dissolved and are known as microtags. These microtags are more important due to their larger number and greater surface area of contact. Micro and macrotags within the enamel surface constitute the fundamental mechanism of enamel-resin adhesion.



On dentin: Adhesive resins when applied to the etched and primed dentin surface, they will diffuse and infiltrate the demineralized wet-primed exposed collagen layer and fill the interfibrillar spaces covering exposed collagen fibrils (forming the hybrid layer) and enter the opened dentinal tubules (forming resin tags) achieving resin-dentin micromechanical bonding.

The adhesive resin is applied actively on the primed surface with a brush and then the excess is removed by controlled air thinning, by bristle brush or microbrush before curing.



Bonding to the inorganic part of dentin involves ionic interaction among the negatively charged group of the bonding agent (for example, phosphates, amino acids and amino alcohols, or dicarboxylates) and the positively charged calcium ions.

Commonly used bonding systems employ use of phosphates. Bonding to the organic part of dentin involves interaction with Amino (–NH), Hydroxyl (–OH), Carboxylate (–COOH), Amide (–CONH) groups present in dentinal collagen. Dentin bonding agents have isocyanates, aldehydes, carboxylic acid anhydrides and carboxylic acid chlorides which extract hydrogen from the above mentioned groups and bond chemically.

Generations of Dental Adhesives

Historically, dentin bonding agents have been classified based on chemistry and the manner in which they treat the smear layer into 7 generations.

The first three generations failed to provide adequate bond strength to dentin. The 4^{th} and 5^{th} generations are E&R adhesives, while the 6^{th} and 7^{th} generations are SE adhesives.

Fourth Generation Adhesives

Fourth generation bonding agents represented significant improvements in the field of adhesive dentistry. These agents are based on "E&R technique" and moist bonding concept.

Mechanism of Bonding

Fourth "generation" is characterized by the process of hybridization at the interface of the dentin and the composite resin. Hybridization is the phenomenon of replacement of the hydroxyapatite and water at the dentin surface by resin. This resin, in combination with the collagen fibers, forms a hybrid layer. In other words, hybridization is the process of resin interlocking in the demineralized dentin surface. This concept was given by Nakabayashi in 1982.

Bonding with 4^{th} generation involve three separate steps; etching, priming and resin bonding.

Advantages

• Ability to form a strong bond to both enamel and dentin.

• High bond strength to dentin (17–25 MPa)

• Ability to bond strongly to moist dentin

• Can also be used for bonding to substrates such as porcelain and alloys (including amalgam).

Disadvantages

• Time consuming

• More number of steps

• Technique sensitive

Fifth Generation Adhesives

Fifth-generation adhesives were made available in the mid-1990s. Similar to the fourth generation, they are based on the E&R technique (a separate step of acid etching is needed). In these agents the primer and adhesive resin are in one bottle. Basic differences between fourth and fifth generation is the number of basic components of bottles.

In this adhesive, only 2 steps are required; 1) separate etching step, and 2) priming and bonding step.

Sixth Generation Adhesives

These were made available in 2000. In sixth generation etching step is eliminated, because in sixth generation; etchant and primer are available in single solution and the adhesive resin in a separate bottle.

Most self-etching primers are moderately acidic with a pH that ranges between 1.8 and 2.5. Because of the presence of an acidic primer, sixth generation bonding agents do not have a long shelf-life and thus have to be refreshed frequently.

In these agents as soon as the decalcification process starts, infiltration of the empty spaces by the dentin bonding agent is initiated

Properties

• Reduces postoperative sensitivity because they etch and prime simultaneously.

• It etches the dentin less aggressively than total etch products.

• Demineralized dentin is infiltrated by resin during the etching process.

• Since they do not remove the smear layer, the tubules remain sealed, resulting in less sensitivity.

• They form a relatively thinner hybrid layer than traditional product, which results in complete infiltration of the demineralized dentin by the resin monomers.

• Much faster and simpler technique.

• Less technique sensitive as fewer number of steps are involved for the self-etch system.

Seventh Generation Adhesives

They achieve the same objective as the sixth generation systems except that they simplified multiple sixth generation materials into a single component, single bottle one-step self-etch adhesive, thus minimizing the number of steps and avoiding any mistakes that could be encountered (the bottle contains all the components which are the weak acid, primer, and the adhesive).

Multimode or Universal Adhesive Systems

Slight modifications of dentin adhesive formulations were made to produce a new class of universal adhesives. These materials are called multimode or universal because they can be used as SE, E&R, or selective enamel-etch systems. These adhesives have the ability to bond methacrylate- based restoratives, cement, and sealant materials to dentin, enamel, glass ionomer, and several indirect restorative substrates, including metals, alumina, zirconia, and other ceramics.

Operative Dentistry

Dr. Mohammed Ayad

Lecture (8)

Caries Activity, Prevention and Treatment and Minimal invasive caries removal methods

Caries activity

Caries lesion can be active or inactive (arrested) lesions. Clinical criteria used to assess the activity of a specific caries lesions in enamel or root are as follow:

1- Appearance: color and luster

2- Texture: roughness and hardness (soft, leathery, firm and hard).

3- Translucency (opaque vs Semitransparent).

4- Presence of plaque (covered by plaque versus plaque free)

5- Cavitation (probing the cavity in enamel reveal either hard or soft base).

Active lesions can be arrested at any stage of its development, if plaque free condition is maintained. If the lesion is arrested, no treatment is required except for esthetic or functional reasons. If the lesion is active, treatment is needed to arrest lesion progression and must include preventive measures. It may also include restorative dentistry. Table 1 shows the clinical appearance of active and arrested caries lesions according to the type or site of the lesion.

Table 1: The clinical appearance of active and arrested caries lesions according to type or site of the lesion.

Type of lesion	Active	Arrested

الاحتواء ليس ان تطيل البقاء ، بل ان تجيد الحضور .

Occlusal lesion	1-Matte or Frosted surface, plaque covered white spot lesion. 2-cavitated lesion; include micro cavities to cavities involving dentine. 3- lesion in dentin visible on bitewing radiograph.	-white or brown spot lesion with shiny surface.
proximal	-lesion appears on radiograph -lesion appears on radiograph with persistent gingival inflammation despite pt. attempt to remove plaque by flossing. -lesion not presents at previous examination.	- Successive, reproducible bitewing radiograph shows no lesion progression deeper.
Smooth surface	-white spot lesion close to gingival margin that may have frosted, plaque covered surface -cavitated, plaque covered lesion with or without exposed dentine, if dentine is exposed & soft, then the dentine is heavily infected with bacteria.	- shiny white or brown lesion & lesions are not plaque covered. - cavitated lesion; dark brown with hard dentine at their base, are not plaque covered & away from gingival margin.
Root surface lesion	- lesion close to gingival margin, plaque covered. -dentin is soft or leathery in consistency	- lesion far from gingival margin, not plaque covered. -as hard as surrounding healthy root surface.

Caries Prevention

Caries preventive treatment is a complex process involving multiple interrelated factors because of the nature of caries disease which is a multifactorial disease. ***Self-applied preventive measures*** (by patients) such as maintaining of good oral hygiene “brushing and flossing”, diet containing sucrose and carbohydrate control, and fluoride toothpastes; all these measures can affect carious lesion initiation (prevention) and also remineralization of the incipient carious lesion specially in smooth surfaces to arrest the carious lesions. If the lesion is arrested, it requires no restorative treatment.

Professionally applied measures (by dentist) such as pit and fissure sealant and fluoride varnish. Fluoride varnishes applied on the surface of the tooth to form calcium fluoride globule deposit because they contain a high level of fluoride (5% NaF, 22,600 ppm F), this deposit can slowly release fluoride and calcium over time to make tooth surface more resistible for acid demineralization. Pit and fissure sealant is the most effective method in preventing pit and fissure caries because they prevent caries by preventing the growth of bacteria that promote decay in pits and fissures in teeth.

Caries treatment

1- Treatment of noncavitated lesions

Non cavitated lesions on occlusal and proximal surfaces of the tooth can be treated by self-preventive measure in addition to the application of occlusal and proximal sealants. When active fissure caries has been diagnosed or if a high risk has been established, sealants may be indicated. Sealants have advantages of preventing progression of active dentin lesions (there is ample evidence that caries lesions do not progress as long as the fissure remains sealed), no cutting of tooth structure needed thus preventing irreversible intervention and its use prevent development of new lesions on other sites of the fissure. On proximal surfaces, Active caries lesions have been treated by application of either adhesives or fissure sealants after temporary tooth separation, However, proximal sealing techniques are as complex to apply and time-consuming as proximal restorations.

A new approach to treat active non-cavitated non-proximal and proximal smooth surface lesions that extend radiographically into inner half of enamel or the outer third of dentin by ***lesion infiltration technique (e.g. ICON caries infiltrant)*** **.** In this technique, a protective low viscosity light curing resin applied on the lesion to occlude the lesion pores and create a diffusion barrier to reduce progression of lesion by changing the cariogenic environment of the lesion and stabilize the fragile structure of the lesion.

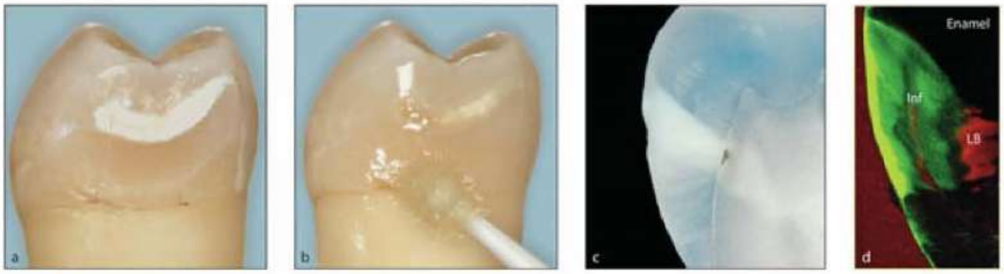
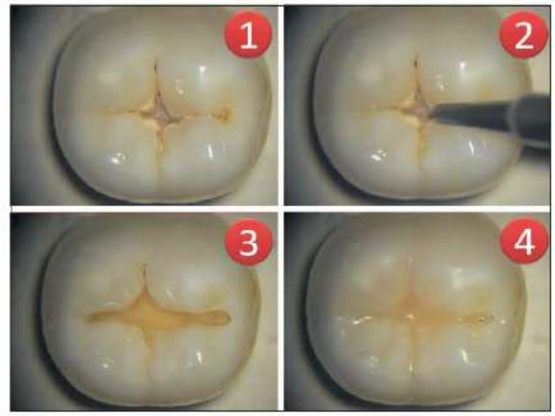


Fig 5-28 Caries infiltration. *(a)* Active noncavitated caries lesions (white spot lesion). *(b)* After application of an infiltrant, the lesion loses its whitish appearance. *(c)* The cross section of a noncavitated proximal caries lesion. *(d)* Confocal microscopic image of an infiltrated lesion. The infiltrant (Inf) is shown in green, whereas the remaining pores within the lesion are shown in red. The infiltrant almost completely penetrates the lesion body (LB) and thereby acts as a diffusion barrier inside the lesion. (Courtesy of Sebastian Paris and Hendrik Meyer-Lückel, Aachen, Germany.)

2- Treatment of cavitated lesions

Once caries has produced cavitation of the tooth surface (i.e., the lesion is active and there is a dentin involvement), preventive measures are usually inadequate to prevent further progression of caries, because plaque stagnate in non-cleansable cavities and enhance lesion progression, therefore cavity preparation and restoration are needed. However, the most important reason for placing a restoration is to aid plaque control and attempt should be made to select the most conservative treatment option to prevent iatrogenic damage during cavity preparation such as damage of proximal surfaces of adjacent teeth. Indications of restorative treatment are: sensitivity of the cavitated tooth to hot, cold and sweetness, non-cleansable deep occlusal and proximal caries lesion extending into dentin, lesion endangering the pulp, disability of patient to provide home care, loss of proximal contact, unesthetic appearance of the tooth. Once the pulp is dead partially or completely; root canal filling become necessary to avoid tooth extraction.

New Technologies for Caries Removal and Cavity Preparation (Minimal Invasive cavity preparation)



1. **Air abrasion:** air abrasion removes tooth structure (enamel and dentin) using a steam of aluminum oxide particles generated from compressed air. The abrasive particles strike the tooth with high-velocity and remove small amount of tooth structure.

Clinical application of air abrasion includes:

- Detection of pit and fissure caries.
- Removal of superficial enamel defects.
- Cleaning fissures and surface preparation for sealant preventive resin restoration.
- Small class I and V preparation.

Advantages:

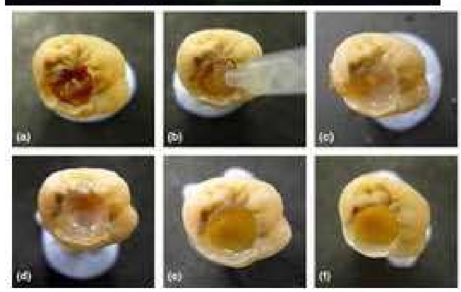
1- No heat, pressure, vibration and sound
2-Reduce need for anesthesia
3-Minimal cutting of tooth structure
4-Dry operative field
5-Reduce risk of micro-crack and chipping of tooth structure

Disadvantages:

1-Air jet can cause sensitivity
2-Not recommended for deep cavities
3-Only composite resin can be used after air abrasion cavity preparation.
4-Lack of tactile sensation
5-Impair indirect vision
6-Cause damage to dental mirror

2. **Chemo mechanical method:** The CMCR idea has been developed first while using Sodium hypochlorite (NaOCl) in removing the organic material from the root canal during endodontic

treatment, it has been showed that this chemical have the ability to selectively dissolve the carious dentin by disrupting the hydrogen bonding in the partially degraded collagen bundles of the infected dentin rendering it more friable and easier to remove by scrapping using specially design hand instrument, leaving well organized affected dentin. This reduces the removal of sound tooth structure, pulpal irritation and pain compared with conventional rotary method using burs. Examples: Carisolv.



Advantage:

- Reduce the need for L.A (reduce cost and anxiety).
- Conservation of tooth structure (no cavity overpreparation).
- Reduce risk of pulp exposure
- No noise, vibration and heat
- The most important advantage is the selective removal of caries infected dentin and leaving the caries affected dentin.

Disadvantage:

1- Time consuming
2- Still need for hand instrument
3- Expensive
4- only can be used with composite resins (no amalgam restorations).
5- limited shelf life

3. **Laser devices:** Lasers are used to remove decay within a tooth and prepare the surrounding enamel for receipt of the filling. It based on the ablation mechanism in which hard dental tissue is removed by phoptovaporization of water within the tooth which

create high pressure act in destroy and remove selective area of the tooth. direct water steam is important to reduce heat buildup.

Advantages

1- Comfortable and eliminate need for L.A

2-no vibration or noise

3- conservation of sound tooth structure

4- increase surface area available for bonding of composite restorations

5- ideal for children and adult

e.g. Er:YAG laser device, and laser-powered hydrokinetic system (LPHKS).

4. Smart bur (Smartprep)

The Smartprep bur is a polymer that safely and effectively remove decayed dentin, leaving healthy dentin intact.

The polymer instrument is self-limiting and will not cut sound dentin unless applied with great force, and then it will only wear away, rather than cut the healthy dentin. The self-limiting polymer is unlikely to mechanically expose dentinal tubules and unlikely to cause patient discomfort. In many cases, no local anesthesia is required for patient comfort. It is used with low speed handpiece, single patient use.

Advantage:

1.Less chance for iatrogenic pulp exposure

2.Minimal removal of sound tooth structure

Disadvantage:

1. According to studies, it has been concluded that this technique leaves large amount of decayed portion unexcavated.
2. Expensive
3. Chance of damage if the bur touches enamel or sound dentin during or after preparation

5. Ozone treatment

The ozone delivery system is a device that takes in air and produces ozone gas. The ozone is then delivered via a hose into a disposable sterile cup. The ozone gas is refreshed in this disposable cup at a rate of 615 cc/minute changing the volume of gas inside the cup over 300 times every second. The cup forms a seal around the lesion being treated so that ozone cannot leak into the oral cavity.

Around 20-40 seconds of ozone application have been shown to penetrate through carious dentin to eliminate any live bacteria, fungi, and viral contamination. This treatment eliminates cariogenic organisms as well as priming the tissues for remineralization.

Advantage:

- Non-invasive, painless method
- do not cause allergy.
- microorganisms do not develop resistance to ozone
- decrease treatment time (20-120 sec per lesion)
- the studies shows that 75-100% of ozone treated lesions become harder during 1year period

Operative Dentistry

Dr. Mohammed Ayad

Lecture (4)

Patient Evaluation, Diagnosis and Treatment Planning (Part II)

D. Evaluation of existing restorations

The following criteria are used to evaluate existing restoration:

1. **Structural integrity:** this evaluation involves determining whether it is intact or whether portions of the restoration are partially or completely fractured or missing. The presence of fracture line indicates replacement of the restoration.
2. **Marginal opening:** for amalgam restorations the existence of marginal ditching does not indicate the replacement of the restoration; because the margins of amalgam restorations become relatively well sealed by the accumulation of corrosion products, unless signs of recurrent caries are present.

   For composite restoration, the marginal gap should be considered for repair or replacement of the restoration. The presence of marginal gap is less critical for restorations with anticariogenic properties, e.g. glass ionomer cement. Because studies have shown that tooth structure adjacent to GI cement restorations is less susceptible to caries; replacement of the restoration is only indicated when tooth structure adjacent to the marginal gap becomes carious or when there is marginal staining (that is esthetically unacceptable) especially in anterior teeth.
3. **Caries:** the dentist must use a combination of visual, tactile and radiographic examinations to detect the presence of caries lesion. A radiolucent area surrounding a radiopaque restoration or the presence of soft tooth structure generally indicates caries and must be repaired or replaced.
4. **Restoration-related periodontal health**: examination of restorations must include an assessment of the effect that existing restoration have on the health of the adjacent periodontuim. Problems commonly encountered in this area are:

a. Surface roughness.
b. Interproximal overhangs.
c. Impingement on the zone of attachment (called the biologic width) [the area approximately 2-3mm in the apicocoronal dimension, occupied by the junctional epithelium and the connective tissue attachment].

All three of these phenomena can cause inflammation within the periodontium. Open or rough subgingival margins can harbor bacterial plaque to generate an inflammatory response. Gingival inflammation around crown may also due to an allergic reaction to material in the crown.

5. **Occlusal and interproximal contacts**: all interproximal contacts should be assessed with thin dental floss by the dentist. Contacts should allow the smooth passage of floss. Contacts that are open or excessively tight should be evaluated to determine whether pathosis, food impaction or annoyance to the patient has resulted.

   The occlusal contacts of all restorations should be evaluated to determine whether they are serving their masticatory function without creating a symptomatic or pathogenic occlusion. Restorations whose occlusal contacts are creating primary occlusal trauma should be altered or replaced to resolve the problem. Restorations that are in significant infra-occlusal may permit the super eruption of opposing teeth and should be considered for replacement.

6. **Esthetics:** some of the more common esthetic problems found in the existing restoration are:
   a. Display of metal.
   b. Discoloration or poor shade match in tooth colored restoration.
   c. Poor contour in tooth-colored restoration.
   d. Poor periodontal tissue response in anterior restoration.

E. Evaluation of Occlusion and Occlusal Wear

The occlusion can have significant effects on the restorative treatment plan. The following factors should be evaluated during occlusal examination:

1. Occlusal interferences between the occlusion of centric relation and that of maximum intercuspation.
2. The number and position of occlusal contacts as well as the stress placed on the occlusal contacts.
3. The amount and pattern of attrition of teeth and restorations resulting from occlusal function.
4. The interarch space available for placement of needed restoration.

The number and position of occlusal contacts strongly influence the selection of restorative materials as well as the design of the preparation and restoration.

Attrition: excessive occlusal wear caused by occlusal parafunction (bruxism). In these instances, facets on opposing teeth match well. Prevention is accomplished with use an occlusal resin appliance (night guard, bite plane), and education of the patients.

F. Evaluation of tooth integrity and fractures

Cracked-tooth syndrome: is a fairly common result of incomplete tooth fracture. Patients suffering cracked tooth syndrome often experience cold sensitivity and sharp pains of short duration while chewing. The cusps most commonly fractured are the nonfunctional cusps. Often patients with multiple cracked teeth have parafunctional habits or malocclusions. Cracked-tooth syndrome is an age-related phenomenon, the greatest occurrence is found among patients between 33-50 years of age.

This syndrome is often difficult to diagnose. The patient is unable to identify the offending tooth and evaluation tools such as radiograph, visual examination, percussion and pulp tests are typically non diagnostic.

The two most useful tests are:

- **Transillumination:** when a tooth with a crack is transilluminated from either the facial or lingual direction, light transmission is interrupted at the point of the crack. This results in the portion of the tooth on the side away from the light appearing quite dark.
- **Biting test**: it is the most definitive means of localizing the crack, by having the patient bite a wooden stick, rubber wheel; the dentist will be able to reproduce the patient's symptom and identify the fractured tooth.

In treatment of incomplete tooth fracture, the tooth sections are splinted together with a cuspal coverage restoration. This may include the use of an amalgam or composite restoration, a crown or indirectly fabricated onlay.

G. Esthetic Evaluation

In addition to an esthetic evaluation of existing restorations, an assessment of the esthetics of the entire dentition should be completed. Commonly encountered esthetic problems that are related to restorative dentistry include:

1. Stained or discolored anterior teeth.
2. Unaesthetic contours in anterior teeth (length, width, incisal edge shape or axial contour).
3. Unaesthetic position or spacing of anterior teeth.
4. Carious lesions and unaesthetic restoration.
5. Unaesthetic color and/or contour of tissue adjacent to anterior restorations, this includes: excessive gingival display occasionally referred to as the (gummy smile).

The restorative treatment of esthetic problems may range from conservative therapy such as micro abrasion or bleaching to more invasive care such as the placement of resin veneers, ceramic veneers, or complete coverage crowns.

Additionally periodontal, endodontic or orthodontic procedures may be helpful depending on the nature of the problem.

2. EVALUATION OF THE PERIODONTIUM

From a restorative dentistry perspective, the periodontium must be evaluated for two reasons:

- To determine the effect that the periodontal health of the teeth will have *on the restorative dentistry treatment plan.*
- To determine the effect that planned and existing restorations will have *on the health of the periodontium.*

Evaluation of periodontium consists of a clinical assessment of attachment levels, bony support, tooth mobility, qualitative assessment of tissue health, and radiographic evaluation of supporting bone.

The most consistent clinical indicator of inflammation is bleeding on probing. Any bleeding by gentle probing should be noted.

The qualitative assessment of periodontal tissue health includes tissue color, texture, contours, edema and sulcular exudates are noted. The presence of specific local factors such as plaque, calculus and their relationship to tissue inflammation should be noted.

During examination of periodontium, the dentist must estimate the location of margins for future restorations and their potential to impinging on the biologic width.

3. EVALUATION OF RADIOGRAPH

The radiographic examination is an essential component of the comprehensive evaluation. Clinical situations for which radiograph may be indicated includes:

-Previous periodontal or root canal therapy.
-History of pain or trauma.
-Large or deep restorations.
-Deep carious cavity.
-Swelling and mobility of teeth, fistula or sinus tract infection.
-Abutment teeth for fixed or removable partial prosthesis.
-Unusual tooth morphology or color.
-Missing teeth with unknown reason.

In evaluating radiographic findings for restorative purposes, the dentist should note open interproximal contacts, marginal openings, overhanging restoration, periapical radiolucencies within the bone of the tooth.

The dentist must interpret abnormal radiographic finding with caution. For example when the clinician evaluates radiolucencies that appear to represent carious tooth structure but may in fact represent nonpathologic processes as in a radiographic phenomenon known as (burnout) which is a radiolucency not cause by caries, it occurs when x-ray beam traverses a portion of the tooth with less thickness than surrounding areas most commonly seen in cervical area of the tooth. So the dentist must be careful not to mistakenly diagnose as demineralized tooth structure. Also the dentist must be cautious in diagnosing caries beneath existing restorations because certain radiolucent dental materials have a radiographic appearance similar to that of carious tooth structure.

4. **EVALUATION OF DIAGNOSTIC CASTS**

   The dentist can gain valuable information through an evaluation of diagnostic casts. The dentist can see areas that are visually inaccessible during the clinical examination. Facets and marginal openings that may be difficult to see intraorally are readily visible on the diagnostic casts. Also cases involving multiple missing teeth need the evaluation of casts mounted on a semi-adjustable articulator. This enable dentist to assess the occlusal relationship and to plan restorative treatment.

Treatment Plan

Having completed a comprehensive examination, the dentist lists the problem related to restorative dentistry. Planning the restoration of individual teeth requires the consideration of four factors:

1. The amount and form of remaining tooth structure.
2. The functional need of each tooth.
3. The esthetic needs of each tooth.
4. The final objective of the overall treatment plan.

Treatment Sequence

When the completed treatment has been visualized and the design of the restorations required has been established the final step in establishing the restorative dentistry treatment plan is sequencing the treatment.

Restorative treatment aimed at the control of active disease generally consists of direct restorative procedures using amalgam, resin composite or glass ionomer material. The sequence of treatment within the disease-control phase is dictated by three considerations:

1. Severity of the disease process (i.e. the most symptomatic tooth, the tooth with the deepest lesion, or the most debilitated tooth is restored).
2. Esthetic needs.
3. Effective use of time.

At each appointment, treatment is rendered in the area in most acute need of restorative treatment. When possible the restorations should be completed quadrant by quadrant to optimize the use of time.

Operative Dentistry

Dr. Mohammed Ayad

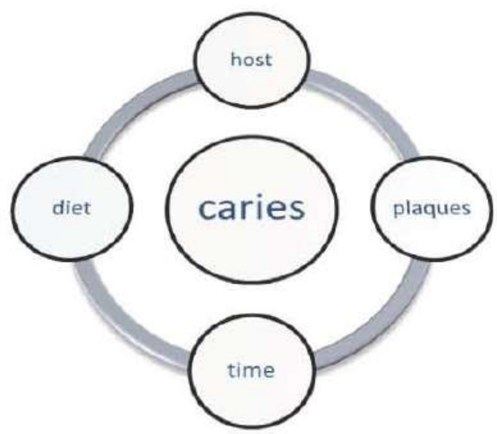
Lecture (6)

Management of dental caries in enamel and dentin (classification, diagnosis, prevention, and treatment)

Dental caries is an infectious microbial disease of the teeth that results in localized dissolution and destruction of the calcified tissues.

It is essential to understand that cavitations in teeth are signs of bacterial infection (mostly *Mutans Streptococci* and *Lactobacilli*). Carious lesions only occur under a mass of bacteria (dental plaque) capable of producing a sufficiently acidic environment to dissolve tooth structure. The plaque bacteria metabolize refined carbohydrates for energy and produce organic acids as bi-products. The acids produced may then cause a carious lesion by dissolution of the tooth's crystalline structure.

Dental caries is a multi factorial disease; it is the result of complex interaction between ***Host, Plaque, Diet,*** and ***Time***.



The initiation and progression of caries is affected by other factors such as saliva, fluoride, preventive measures, etc..

1-Host Factors

A-Teeth

The teeth vary in their susceptibility to dental caries from one surface to another and from one subject to another. There are several factors affecting tooth susceptibility as:

Morphology of teeth:

Susceptible sites on the tooth, which favour plaque retention and stagnation, are prone to decay.

These include:
1- Enamel pits and fissures.
2- Approximal enamel smooth surfaces.
3- Cervical margin of teeth.
4- Exposed root surfaces because of gingival recession.
5- Deficient or over hang restoration (recurrent caries).
6- Tooth surfaces adjacent to denture and bridges.

Composition of teeth:

Teeth are composed of inorganic elements (96% in enamel, 70% in dentin), organic elements and water. Composition of teeth is effected by environmental factors (water, diet, and nutrition).

Inorganic components: involve *major elements* as calcium, phosphate, hydroxyl group these are the constituents of hydroxyapatite crystals.

As the pH decreased, calcium phosphate minerals become susceptible to demineralization. As the environmental pH recovers, dissolved calcium & phosphate can re-precipitate and the process called (remineralization).

B-Saliva: Saliva can affect caries etiology and progression through the *rate of secretion* and *composition*.

- Saliva affects the integrity of teeth by the composition of buffer system (calcium and phosphate).
- By the cleansing action of saliva (oral clearance), it can reduce the number of oral micro organisms and food debris from the mouth.
- Saliva can provide antibacterial agents through *oral immune system* (specific and non specific) that can minimize the number of cariogenic bacteria.

C-Subject*:* The behaviour, attitude and dental knowledge can affect the caries initiation and progression. These can influence the oral hygiene of the person as well as his dietary habits.

D-Social & demographic factors: many studies have shown that dental caries is more prevalent in the lower socioeconomic categories.

F-Fluoride: it reduces tooth demineralization through the formation of fluorhydroxyapatite and fluorapatite crystals, and through accelerating and promoting reminerlization of a previously demineralized tooth structure.

2-Dental plaque: A gelatinous mass of bacteria adhering to the tooth surface.

Carious lesion only occurs under a mass of bacteria capable of producing a sufficiently acidic environment to demineralize tooth structure.

Plaque quantity and quality greatly influence caries etiology. Bacteria adhere to tooth surface and ferment carbohydrate causing release of acid that demineralizes the tooth surfaces. Cariogenic bacteria include *mutans streptococci, Lactobacilli* and others.

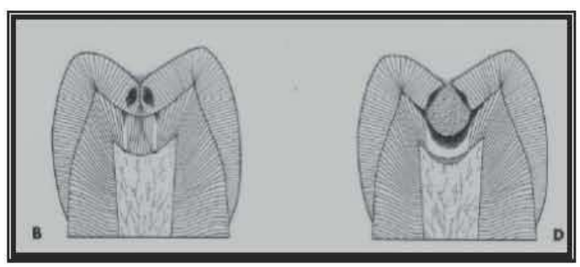
Mutans Streptococci → early carious lesions of enamel.

Lactobacilli → dentinal caries.

3- Diet: dietary carbohydrates are necessary for the bacteria to produce the acids that initiate demineralization.

CLASSIFICATION OF DENTAL CARIES

The characteristics of the carious lesion vary with the nature of the surface on which the lesion develops.

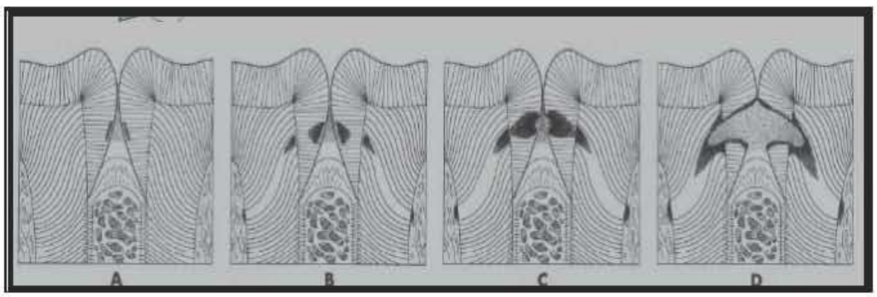


1. The first and most susceptible site is in the *developmental pits and fissure* of the enamel.

The shape of pits and fissures contributes to their high susceptibility to caries. Pit and fissure caries expand as it penetrates into the enamel affects a greater area of DEJ. Thus the entry site may appear much smaller than the actual lesion. In cross section, the gross appearance is an inverted V (or triangle) with a narrow entrance and a progressively wider area of an involvement closer to the DEJ.

2. The second site is on certain areas of the *smooth enamel surfaces* were contour or tooth position protects plaque against the rubbing action of some foods and often from being loosened by toothbrush, these include the areas of contacting proximal surfaces which are gingival to the contact area. Other susceptible smooth enamel surfaces are those areas gingival to the height of contour of the facial and lingual surfaces.

Lesions starting on smooth enamel surfaces have a broad area of origin and a conical, or pointed, extension toward the DEJ. A cross section of the enamel portion of a smooth surface lesion show a V shape (or triangle) with a wide area of origin and the apex of the V directed toward the DEJ. After caries penetrates the DEJ, softening of the dentin spread rapidly laterally and pulpally.



3. The third site where caries may attack is the *root surface*. The root surface is rougher than enamel and readily allows plaque formation in the absence of good oral hygiene. The cementum covering the root surface is extremely thin and provides little resistance to caries attack. Root caries lesions have well defined margins, tend to be U-shaped in cross section, and progress more rapidly due to the lack of protection from an enamel covering; in addition to the fact cementum begins to demineralize at pH 6.7, which is higher than the enamel's critical pH of 5.5. It has been notable increase in prevalence of root caries, probably due to the increasing number of older persons who experience gingival recession and usually have cariogenic plaque on exposed root surface.

<u>In addition, caries could be classified according to the type and severity of the lesion into:</u>

1. *Acute caries "rampant"*: is a rapid progressing involving a large numbers of teeth. The acute lesions are lighter colored than other lesion, being light

brown or gray and their carious consistency makes the excavation difficult. Pulp exposures are often observed in patient with rampant caries.

2. *Chronic caries*: these lesions are usually of long standing involvement affect of fewer numbers of the teeth and are smaller in size than acute caries.

3. *Primary caries "Initial":* is one in which the lesion constitutes an initial attack on the tooth surface. It designated as primary because of the initial location of the lesion on the surface rather than on the extended damage.

4. *Secondary caries "Recurrent"*: this type is observed around the edges of restoration. Surface overhanging margin and fracture on the surfaces in posterior teeth that are naturally prone to caries because of difficult in cleaning.

PROGRESSION OF CARIES

The progression and morphology of caries lesion is variable depending on the site of origin and the conditions in the mouth. The time for progression from incipient caries to clinical caries (cavitation) on smooth surface is estimated to be 18 ± 6 months. Peak rate for the incidence of new lesion occurs 3 years after the eruption of the tooth.

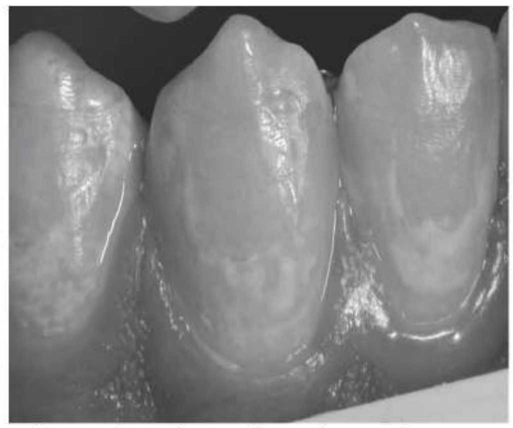
Occlusal pit and fissure lesions develop in less time than smooth surface caries. Both poor oral hygiene and frequent exposures to sucrose containing-food can produce *incipient* (white) lesions (first clinical evidence of demineralization) in as little as three weeks. The volume and buffering capacity of saliva available to tooth surfaces has a major role in caries protection. The buffering capacity of saliva is primarily determined by the concentration of bicarbonate ion. The benefit of the buffering is to reduce the potential for acid formations. Once the pH falls below 5.5, tooth minerals begins to dissolve and the calcium and phosphate ions leaves enamel surface towards the adjacent plaque. When the pH returns high (above 5.5), remineralization of damaged tooth structure can occur before the initiation of cavitation.

Radiation induced xerostomia (dry mouth) can lead to clinical caries development in as little as three months from the onset of radiation. Thus caries development in healthy person is slower in comparison to the rate in compromised persons.

CLINICAL CHARACTERISTIC OF ENAMEL CARIES

On clean, dry teeth, the earliest evidence of caries on smooth enamel surface of crown is a white spot. These lesions are usually observed on the facial and lingual surfaces of the teeth. White spot are chalky white, opaque areas that are revealed only when the tooth is dried, and termed ***incipient caries***. These areas of enamel lose their translucency because of the extensive subsurface porosity caused by demineralization.

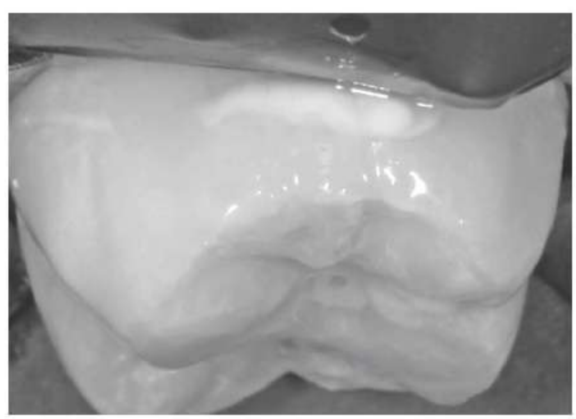
Care must be exercised to distinguish white spots of incipient caries from ***developmental white spot hypocalcifications*** of enamel. Incipient caries partially or totally disappear visually when the enamel is hydrated (wet), while hypocalcified enamel is unaffected by drying and wetting. Hypocalcified enamel does not represent a clinical problem except when its appearance is objectionable esthetically.



A more advanced lesion develops a rough surface that is softer than the unaffected, normal enamel, softened chalky enamel that can chipped a way with an explorer is a sign of ***active caries.***

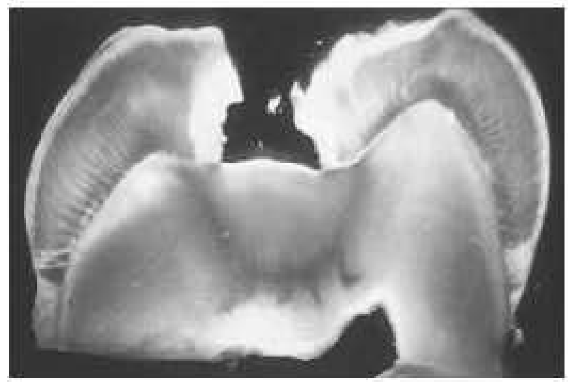
Incipient caries can be remineralized. Non cavitated enamel lesion retain most of the original crystal framework of the enamel rods and the etched crystallites serves as nucleating agents for remineralization..

Calcium and phosphate ions from saliva can then penetrate the enamel surface and precipitate on the highly reactive crystalline surfaces on the enamel lesion. The change in color (to brown or black spots) is due to trapped organic debris and metallic ions within the enamel. These lesions which are termed ***"Arrested caries"*** are more resistance to subsequent caries attack than the adjacent unaffected enamel. They should not be restored unless they are esthetically objectionable.



CLINICAL CHARACTERISTIC OF DENTINAL CARIES

Dentinal caries is a V- shaped in cross section with a wide base at the DEJ, and the apex directed pulpally. Caries advance more rapidly in dentin than in enamel because dentin provides much less resistance to acid attack. Caries produces a variety of responses in dentin, including pain, demineralization, and remineralization.



Often, pain is not reported even when caries invades dentin, except when deep lesions bring the bacterial infection close to the pulp. Once bacterial invasion of the dentin is close to the pulp, toxins and even a few bacteria inter the pulp, resulting in inflammation of the pulpal tissues.

Initial pulpal inflammation is thought to be evident clinically by production of sharp pains for only a few seconds (10 or less) in response to a thermal stimulus. A short, painful response to cold suggests ***reversible pulpits*** or ***pulpal hyperemia***. Reversible pulpitis is a limited inflammation of the pulp from which the tooth can recover if the caries producing the irritation is eliminated timely by operative treatment.

When the pulp becomes more severely infected, a thermal stimulus will produce pain that continues after termination of the stimulus, typically longer than 10 seconds (partial or total pulp necrosis). This clinical pattern suggests ***irreversible pulpitis*** which need endodontic treatment.

Operative Dentistry

Dr. Mohammed Ayad

Lecture (7)

Caries Detection, Diagnosis and New Caries Detection Methods

CARIES DETECTION AND DIAGNOSIS

Caries: Caries is a dynamic process of demineralization and remineralization of dental hard tissue which may result in progression, regression (reversal), or arrest (stabilization) of the lesion. When demineralization (loss of minerals "hydroxyapatites crystals") outgain remineralization (gain of minerals), caries progresses which occur in case of frequent eating (which lead to continuous reduction in pH of oral environment) and inadequate use of fluorides.

Caries detection and diagnosis:

Caries detection involves determining whether or not clinical signs of caries are present at one point in time. On the other hand, ***caries diagnosis*** is the determination of activity and causes of the caries lesion in addition to caries detection. Caries detection process can be performed by mixing of information obtained from:

1- Clinical examination
2- Use of caries diagnostic aids
3- Communication with patient
4- Knowledge about caries process

Aim of detection of early caries lesions

The aim of detection of early carious lesions is to limit the progression of caries as early as possible and monitor caries lesion activity. Early caries is a reversible disease and can be prevented by prevention of demineralization and promotion of remineralization by an effective prophylactic intervention which employed to reverse or arrest the lesion before the need for restorative intervention.

Methods of caries detection

The conventional caries detection methods are visual and radiographic examinations. Visual examination of early caries lesion can be seen either as a white or as a brown/black spot lesion (Fig). There are noncavitated and cavitated stages of progressed dental caries that can be identified and described using clinical signs.

Fig 5-7 The first clinical sign of caries: a chalky and matte whitish surface.

Fig 5-8 White spot lesion discolored by staining has turned into a brown spot lesion.

Detection of carious lesions with visual examination must be performed while the teeth are:

1. cleaned from plaque by a probe or a prophylactic cleaning.
2. dried with air-water syringe for more than 5 seconds, because removing water from the porous tissue enables the dentist to gauge how far through the enamel a lesion has progressed.
3. Use of magnification devices such loupes or operating microscope can improve caries detection by 50%.

Caries detection in different types of lesions

1. Pit & fissure lesions:

-Detection of these lesions most often performed by visual inspection. Good lightening & dry clean teeth. It appears that any sign of visible cavitation in the occlusal surface corresponds to the progression of the lesion into the dentin. Opaque, matte texture of enamel adjacent to the stained pits and fissures may indicate the presence of active caries underneath the pit and fissure. When there is no caries underneath, discoloration will remain within the confines of the pit and/or fissure.

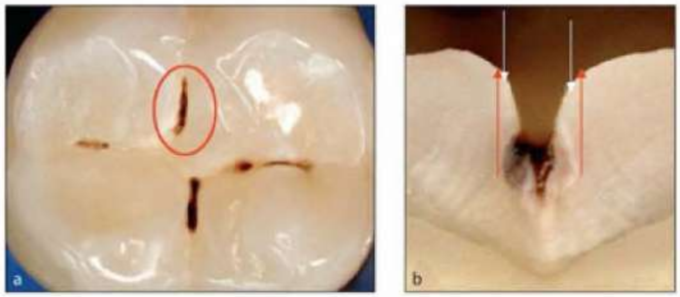
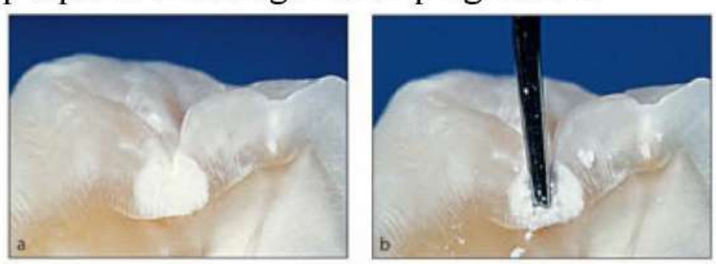


Fig 5-10 Illustration of the visual detection of lesions on the walls of stained pits/fissures. *(a)* A stained fissure *(red circle)* under visual examination. *(b)* Looking perpendicularly through the translucent adjacent healthy enamel along the fissure *(white arrows)*, lesions on the walls of the fissure are seen as discoloration extending (ie, underneath the translucent enamel) beyond the confines of the fissure with a "bottle-brush" appearance *(red arrows)*.

-Bite-wing radiographs can detect only large occlusal lesions. Small lesions can't be detected with bitewing radiographs because of the large amounts of surrounding sound enamel.

Radiograph shows large pit and fissure caries lesion.

-Tactile examination of fissures with sharp probe is unreliable method because the explorer can damage a white spot lesion by breaking through intact surface zone & cause a cavity which will trap dental plaque & encourage lesion progression.



b) The explorer tip can easily damage white spot lesions.

2. Lesions involving proximal surfaces:

- Extensive active proximal lesions can be revealed by shadowing or grayish discoloration of the undermined occlusal enamel ridge.

- Bitewing radiographs are the most effective method for evaluation of the proximal smooth surfaces for evidence of demineralization because these areas are not readily assessed visually or tactilely when there is contact between proximal surfaces. The radiograph should be assessed to determine penetration of the lesion either into enamel, DEJ, outer half or in the inner half of dentin. However, the bitewing radiograph still cannot distinguish between cavitated and noncavitated proximal lesions.

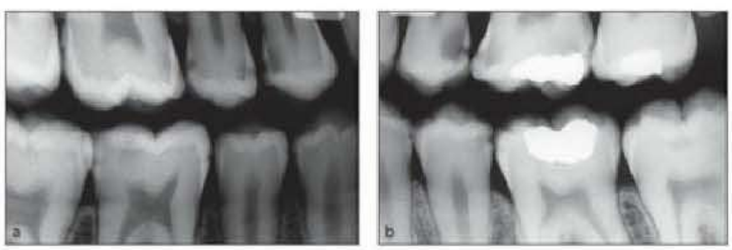
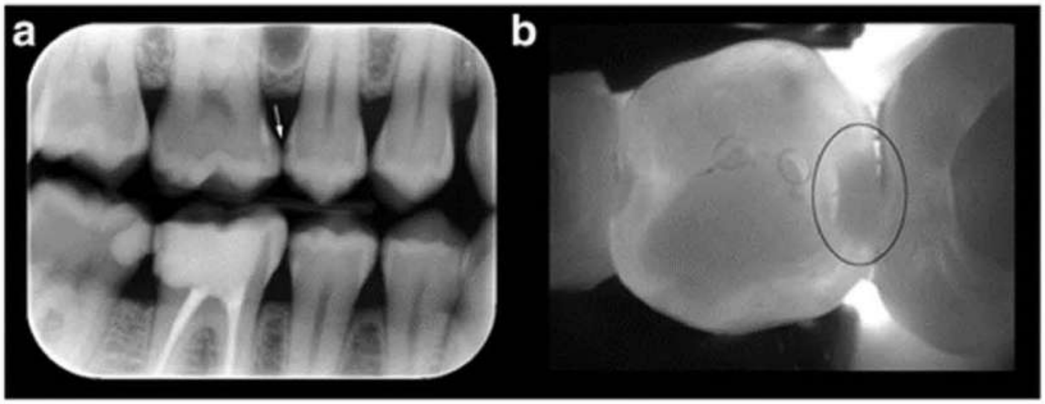


Fig 5-13*(a and b)* Radiographs showing proximal demineralizations in the outer enamel to the dentinoenamel junction and in the outer and inner half of dentin. (Occlusal lesions are visible on the mandibular left second molar and right first and second molars, and a recurrent caries lesion is underneath the restoration on the maxillary left first molar.)

- Fiberoptic transillumination techniques have proven useful in detection of proximal caries lesion. In these techniques, a fine light is transmitted through the contact area. Lesions appear as a dark shadow; however, it is difficult to determine penetration of lesion into enamel or dentin.



- The use of orthodontic separator has been advocated in some cases to allow the dentist to see more clearly & gently feel for a break in the enamel surfaces.

2. **Lesions in smooth free surfaces (buccal and lingual):** lesions in enamel of smooth free surfaces of the crown usually located close to the gingival margin and characterized by chalky matte, whitish/ yellowish surfaces.

4. **Root surfaces:** Root surfaces exposed to the oral environment, usually due to gingival recession, are at risk for caries and should be examined visually and tactilely. Discoloration of such areas (light brown, dark brown, or black discolored area on the root surface or at the cementoenamel junction) is common and usually is associated with remineralization. Generally, the darker the discoloration, the greater the remineralization. On the other hand, active, progressing caries shows

little discoloration and is primarily detected by the presence of softness and cavitation.

New Caries Detection Methods

The conventional caries detection methods, visual and radiographic examination, cannot quantitatively measure the continued changes in mineral status of the caries lesion. The development of several new devices and detection methods is promising. Most of these devices claim to detect and monitor caries activities based on the change in the reflectance, transmission, fluorescence, electrical conductance/ impedance properties of enamel following demineralization.

Reasons for employing new caries detection methods are:

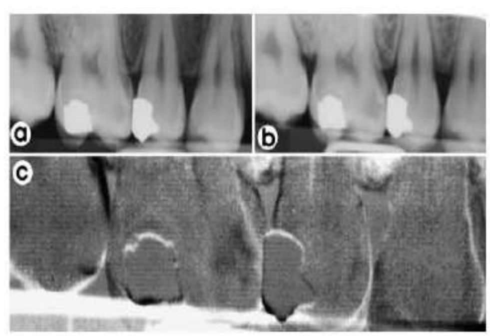
- Early lesion detection as well as hidden occlusal lesions detection.
- Objective and quantitative lesion assessment (for monitoring purposes).
- Visualization of the caries process.
- Avoiding of potentially harmful ionizing radiation.

Electronic caries monitors Sound tooth structure should possess limited or no conductivity whereas, carious enamel should have measurable conductivity that will increase with increasing demineralization (Tooth demineralization due to caries process causes increased porosity of tooth structure. This porosity contains fluid containing ions) Conductivity from the occlusal surface to a ground electrode is measured with a probe. The only drawback is the fact that it is time consuming to use in a routine full-mouth examination. (for example: CarieScan system it is a handheld, battery-operated device).

<u>Direct digital radiographs</u> for caries detection. This system use a wire-based sensor that contains a computer chip inside a protective casing, the sensor is connected to a PC by wire. The sensor is placed in the patient's mouth, when this sensor hit by x-ray the information is transmitted directly to the computer and displayed as an x-ray image on the computer screen. The use of digital radiography permits image manipulation and reduces the amount of radiation required to obtain a diagnostic image. Darkroom is not required; instant image is viewed. Capability for tele-transmission.

Digital Subtraction radiography

Used for detection of recurrent caries. The basis of subtraction radiology is that two radiographs of the same object can be compared using their pixel values. any differences in the pixel values must be due to change in the object. Two standardized radiographs produced with identical exposure and geometry. The reference and the subsequent image for comparison. The reference image is displayed on the screen.



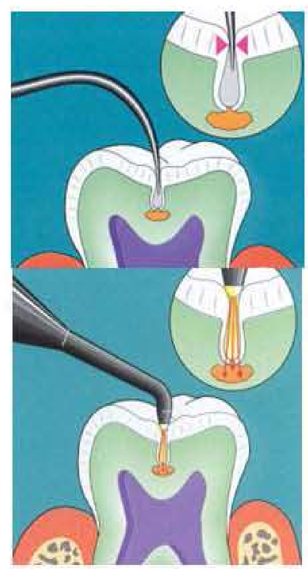
Then the subsequent images are superimposed. The difference between the reference and the subsequent images will show as dark bright areas, which can be interpreted readily. The strength of Digital Subtraction Radiography is because it cancels out the complex anatomic background, against which the subtle changes occurs. As a result, the conspicuousness of the changes is greatly increased. Subtraction images are well-suited for acquiring quantitative information such as linear, area, and density measurements.

Intra-Oral camera for caries detection and for patient motivation.

Magnification using Loupes, and Dental Microscope.

Infrared Laser Fluorescence (DIAGNOdent)

It can be used for detection of caries on occlusal and smooth surfaces.



The principle is that when Diode laser with 655nm wavelength is irradiated on dental surface, it is absorbed by metabolites of caries lesion bacteria and these metabolites emit a red fluorescence. This fluorescence reflected by the dental surface is indicated as a number between 0 and 99 on the screen of the device. The **higher** the number the more is the caries, however, DIAGNOdent is used as a complementary tool beside visual examination for diagnosis of occlusal caries.

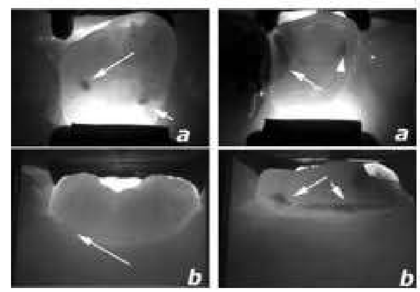
Advantage:

It is most useful in confirming the presence of caries in suspicious fissure and detecting deep dentinal caries (hidden caries). It is non-invasive method for caries detection. However, it is not used for the detection of recurrent caries or to detect proximal caries.

Due to this limitation, a new version of the method was designed and introduced, named DIAGNOdent pen, this new version permits the assessment of both occlusal and proximal surfaces.

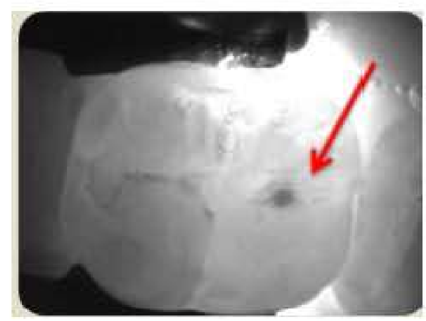
Fiber-optic transillumination

Fiber-optic transillumination (FOTI) as a caries detection technique is based on the fact that carious enamel has a lower index of light transmission than sound enamel. The intact tooth absorbs very little light allowing it free passage. In contrast areas of caries absorb and scatter light thus appear as dark shadow. This method is mainly used to determine proximal caries as well as cracks.



Advantages: 1. Lesions which cannot be diagnosed radiographically can be diagnosed, 2. No radiation hazard, 3. Comfortable to the patient.
Disadvantages: 1. FOTI is not possible in all locations of carious lesions, 2. Cannot detect small lesions

DEXIS CariVu is a brilliant new approach to caries detection combining FOTI with a digital camera which allow immediate imaging and detection of early lesions and can be used on proximal and occlusal lesions.



Contraindication

Large fillings

Crown

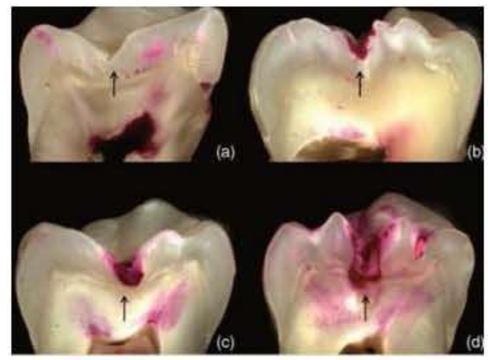
Subgingival caries

Calculus or discoloration can lead to light scattering can be shown like a shade.

Caries detector dyes

Various dyes such as silver nitrate, methyl red have been used to detect carious sites by change of color.

These dyes aid the dentist in differentiation of infected dentin. These dyes enhance the visual recognition of caries by selectively staining the infected demineralized dentin which should be removed during preparation leaving the inner affected dentine (demineralized but not infected) that should be kept and not removed because it could be remineralized.



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Operative Dentistry

Dr. Mohammed Ayad

Lecture (9)

Pulp Irritants

Pulp

Dental pulp consists of 75% water and 25% organic material, this organic material composed of collagen fibers and ground organic substances. Function of organic material is supporting nervous, cellular and vascular components of the vital tooth. Vascularization of the pulp is through the apical foramen which present at the root apex. Pulp tissue is enclosed in a hard dentinal structure of the tooth.

Functions of the pulp

1- Formative: Generates primary, secondary, and tertiary dentin (dentinogenesis)
2- Nutritive: Provides the vascular supply and ground substance transfer medium for metabolic functions and maintenance of cells and organic matrix
3- Sensory: Transmits afferent pain sensation (nociception)
4- Protective: Coordinates inflammatory, antigenic, neurogenic, and dentinogenic responses to injury and noxious stimuli.
5- homeostasis and clearance of noxious and antigenic substances through the vascular and lymphatic systems and through defense cells, such as macrophages and leukocytes.

Pulp irritants

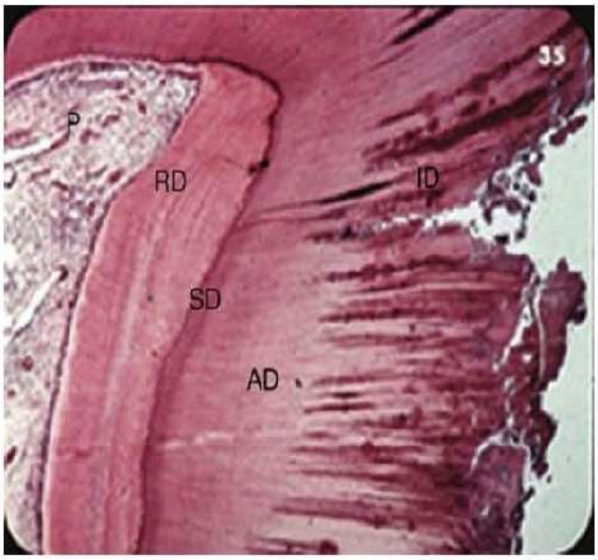
Response of the pulp to external irritation usually accompanied by changes in the dentin (such as sclerosis of dentin, reparative dentin…. etc.), therefore it has been agreed to consider the pulp and dentin as a one organ called the pulp-dentin complex which responds to tooth pathology through pulpal immune-inflammation defense systems and dentin repair/ formation.

Like other soft tissues, the pulp reacts to irritants with an inflammatory response. The pulp irritants can be classified according to the cause of irritant into:

I-Bacterial
II-Physical
III-Irradiation
IV-Chemical

I-Bacterial irritant

1-Caries



Carious enamel and dentin contain numerous bacteria such as *Streptococcus mutans*, *Lactobacilli*, and *Actinomyces*. The population of microorganisms decreases to few or none in the deepest layers of carious dentin. Microorganisms in caries produce toxins that penetrate into the pulp through the dentinal tubules. As a result of the presence of microorganisms and their by-products in the primary dentin, cells in the pulp (mainly odontoblasts)) will respond to this irritation by releasing of cytokines and chemokines that initiate inflammatory reaction and beginning of infiltration of chronic inflammatory cells primarily. As the carious lesion progresses deeper into the dentin and bacterial irritation increase, the pulpal reaction increases as well and the concentration and character of the inflammatory cells' infiltrate change to a more sever type of inflammation.

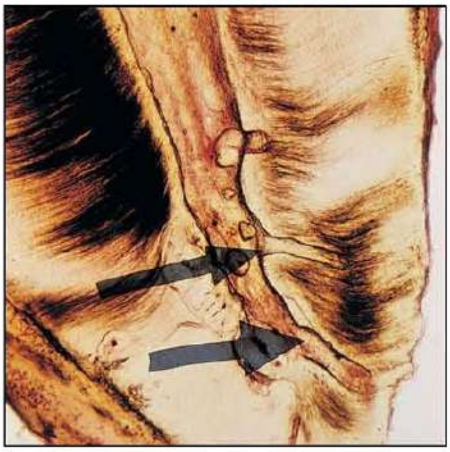
The outward flow of fluid through the dentinal tubules during the primary irritation does not prevent bacteria or their toxins from reaching the pulp and increasing the pulpal inflammation. The extent of the pulpal inflammation beneath a carious lesion depends on the depth of bacterial invasion as well as the degree to which dentin permeability has been reduced by dentinal sclerosis and reparative dentin formation as well as the duration of the irritant.

2-Contamination of an exposed pulp by microorganisms

When actual pulpal invasions by bacteria and/or their toxins occur, severe inflammation occurs and is infiltrated locally by polymorphonuclear leukocytes to form an area of liquefaction necrosis at the site of exposure. Pulpal tissue may stay inflamed for long periods and may undergo necrosis eventually or become necrotic quickly which make the tooth non-vital requiring root canal treatment.

3-Periodontal disease

Periodontal disease may extend to the pulp through the accessory canals (arrows in the figure), the apical foramen, and open dentinal tubules. The inflammatory changes of the pulp occur when teeth have many accessory canals or when periodontal disease has progressed to the apex.



Many studies concluded that the accumulative effect of periodontal disease has a damaging effect on the pulp, as indicated by the presence of pulp calcification, inflammation, or resorption, but total pulp disintegration is certainty only when the apical foramen is infected.

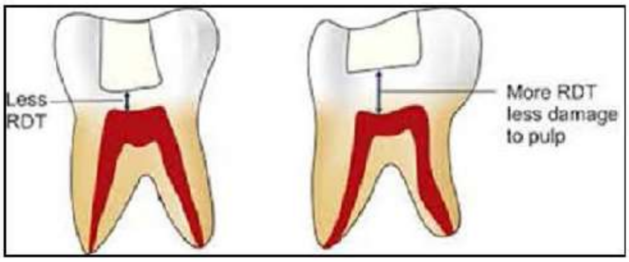
Some studies found that periodontal disease does not have a direct inflammatory effect on the pulp; the initial effect of periodontal inflammation may be degenerative. Root curettage can result in pulp devitalization. During curettage of a periodontal lesion that extends around the apex of a root, the pulp vessels may be severed and the pulp devitalized.

II-Physical irritant

1- Mechanical Irritation

A- Tooth preparation (caries removal or crown preparation)

Pulp trauma results when the pulp is closely approached or the dentin is extensively removed during cavity preparation. Over-cutting during cavity preparation, whether a pulp is exposed or not is one of the greatest damages to the pulp. Not only the depth of cavity affects the pulp, but also the width of the cavity has the same importance. Pulpal damage is roughly proportional to the amount of tooth structure removed as well as to the depth of removal. The remaining dentin thickness (RDT) after deep cavity preparation play a significant role in health of the pulp. Also, it has been noted that there is an inverse relationship between remaining dentine thickness and the pulp injury. This is very important, especially in the case of the acid etching procedure, which is important to increase the longevity of restorations. In teeth with remaining dentine thickness less than 300 µm, acid etching may lead to severe irritation to odontoblasts and persistent inflammation in the pulp due to high permeability caused by acid etching. Also, operative procedures without water coolant cause more irritation than those performed under water spray.



B- Orthodontic movement

The force of movement during orthodontic treatment creates a disturbance in the circulation of the pulp that is similar to those found in the periodontally involved teeth.

If the force is beyond the limitation of the physiologic tolerance, blood vessels in the periodontal ligaments may rupture with a resultant hemorrhage which lead to loss of the nutritional supply to some pulp cells. If hemorrhage occur from larger vessels of the pulp the entire pulp become necrotic. In addition, sometimes orthodontic movement may initiate resorption of the root apex, usually without a change in the vitality of the pulp.

C- Tooth fracture (acute trauma)

Tooth fracture occurs by either direct trauma to the tooth or indirect trauma to the jaw, in addition severe occlusal pressure on a tooth with a large filling can cause fracture of the tooth. Fracture is usually associated with a bacterial invasion that follows the accident. Untreated bacterial invasions will decrease any possibility of sustained vitality of the pulp. If the fracture occurs through the root, this will lead to a disturbance in the vascular supply that often lead to the loss of vitality of the injured pulp.

D- Attrition

Attrition is a mechanical wear of the incisal or occlusal tooth structure as a result of functional or para-functional movements of the mandible (tooth grinding, or bruxism usually due to stress). Pulp inflammation or necrosis related to the incisal wear is seldom, pulp has the ability to lay down dentin, but when a sever worn of the tooth occurs (when attrition exceed the rate of deposition of reparative dentin), pulp exposure with an observable incisal opening could be seen. the pulp may be devitalized at an earlier time and the attrition finally reach the chamber. Sometime the tooth required to be crowned to overcome this problem.

E- Abrasion (chronic trauma)

Abrasion is defined as the loss of tooth structure by mechanical or frictional forces, these lesions are commonly caused by excessive tooth brushing, but repeated and excessive forces by other materials and appliance, such as dental floss, tooth picks, or removable appliances, may also produce such defects.

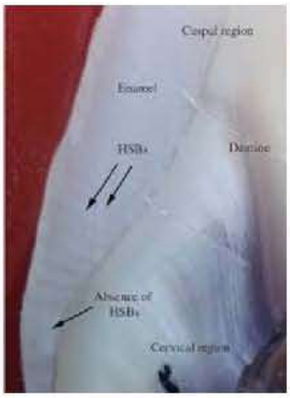
These lesions can progress rapidly if they occur at the cement-enamel junction (CEJ) because the enamel is thin and the mechanical forces can wear the dentin and cementum away quickly. Also, it can be so severe that may invade the pulp space. The lesions commonly caused by horizontal brushing and appear as V- shaped notches on the labial surface.

F- Abfraction

Abfraction is a type of noncarious cervical lesion characterized by the loss of tooth tissues with different clinical appearances.

The theory of abfraction sustains that tooth flexure in the cervical area is caused due to the occlusal compressive forces and tensile stresses, resulting in microfractures of the hydroxyapatite crystals of the enamel and dentin with further fatigue and deformation of the tooth structure. Abfraction lesions are also thought to be facilitated by the thin structure of the enamel and the low packing density of the Hunter-Shreger band at the cervical area.

It is important to determine and eliminate the cause (attrition, abrasion, or abfraction). If the tooth is hypersensitive, it could be relieved by desensitizing agents, topical fluoride, fluoride rinse, dentinal bonding agents, or restoration.



2- Thermal Irritation

It is commonly believed that the various dental procedures, such as tooth preparation, composite resin polymerization, finishing and polishing procedures can cause rise in the intrapulpal temperature. It was reported that an intrapulpal temperature increase of 5.5°C for 10 seconds can cause histological damage in the pulp tissues (irreversible pulpitis or even pulp necrosis).

Two new methods for tooth preparation are available

-Laser

-Kinetic cavity preparation (air abrasion)

Laser device: is a device which produces beams of very high intensity light. There are several types available based on the wavelengths. Laser used for soft and hard tissues, for soft tissue they can produce completely blood free incision followed by rapid healing. The use of a variety of lasers, including CO_2, Er:YAG, and free electron lasers (FEL) on tooth structure has demonstrated minimal pulpal response, comparable to that of high-speed rotary instrumentation.

The effect of laser depends on 1- power of beam 2- extent to which beam absorbed. When we used laser for cutting of enamel and dentin the process would generate heat, which might affect the pulp so it should be used in pulsating manner (not continuously).

-Air abrasion: this generates heat, difficult for operator to determine the cutting progress within the cavity preparation (loss of tactile sensation).

Air abrasive equipment is being used for stain removal and cleansing pit and fissure before sealing. Animal studies have shown that air abrasion cavity preparation is no more traumatic to the pulp than rotary instrumentation.

III-Irradiation irritant

The pulp of teeth is affected in-patient who is exposed to deep radiation therapy for malignant growth in head and neck region. In time odontoblasts cell and other cells will be necrotic and the salivary gland will be affected and resulting in decreasing of the salivary flow.

IV- Chemical irritant

1-Erosion

Erosion is being defined as the loss of tooth structure due to chemical action. Thus, erosion of facial or lingual tooth structure may create lesions. These lesions can be a prominent in patient with oral habits such as constant citrus ingestion, continues exposure to airborne acids, or gastrointestinal problems that produce repeated exposure of teeth to gastric acids. In these cases, the tooth lesions generally present a rounded, cupped-out defect initially confined to the enamel, if left untreated, the loss of tooth structure due to the chemical attack will accelerate once dentin has been reached, and deeper pattern of destruction will be seen.

Difference between dental attrition, abfraction, erosion and abrasion

Attrition Abfraction Erosion Abrasion

2-Chemical irritation of various restorative materials.

ENDODONTICS

Dr. Mohammed Ayad

Lecture (10)

The Rubber Dam and Its Applications

The rubber dam is a disposable aid in endodontic treatment for the following reasons:

1- It prevent accidental swallowing or aspiration of the small, easily dropped endodontic instruments.

2- It prevents intra canal irrigants from entering to the mouth because most of them are of unpleasant taste.

3- It helps to maintain a dry field of operation by eliminating salivary contamination.

4- It eliminates soft tissue interference by retracting the check & tongue.

5- It enhances better concentration of the dentist by showing only the tooth to be treated.

Rubber Dam Materials

It comes in a variety of thickness, colors & sizes.

A) Thickness

(i) Medium – weight: It is indicated in general all around in the mouth.

(ii) Thin – weight: This thickness is indicated in lower anterior teeth & partially erupted posterior teeth.

(iii) Heavy – weight: It has the advantage of providing great adaptation around the teeth & does not tear easily but it exerts much force on the lips & cheek

B) Color

(i) Light. It provides better illumination of the field

(ii) Dark. It provides a sharp contrast between the tooth & the dark background.

C) Size. The rubber dam comes in precut sheets of different dimensions.:

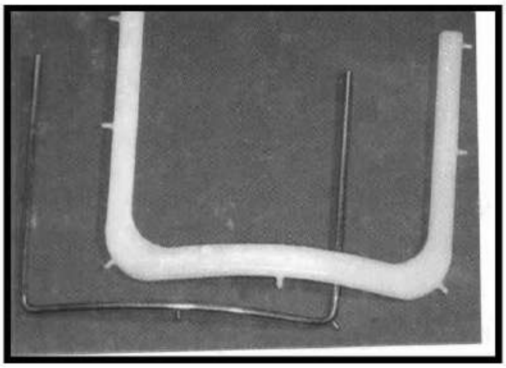
Rubber Dam Frame

The purpose of rubber dam frame is to hold the rubber dam in a manner to:

1) Provide lip & cheek retraction.

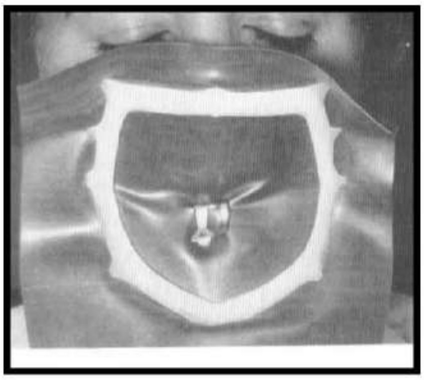
2) Provide unobstructed access to the tooth to be treated.

Types



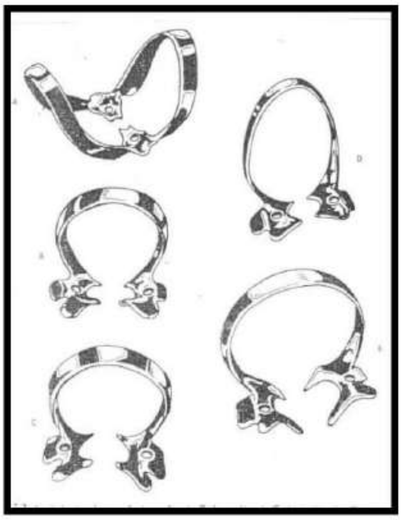
1- Type A. This is called **Young's frame**. It is U– shaped, and made of metal. It might interfere with the X– ray causing obscuring of important structure in the radiograph.

2- Type B. This is called **Starvisi frame**. It is a U– shaped frame, and made from radiolucent plastic & nylon materials. It is regarded as a suitable substitute for Young's frame.



3- Type C. This is called **Nygard – Ostby frame**. It is made from radiolucent plastic & nylon materials & can be left inside the patient's mouth while taking a radiograph without obstruction in the radiograph.

Rubber Dam Clamps



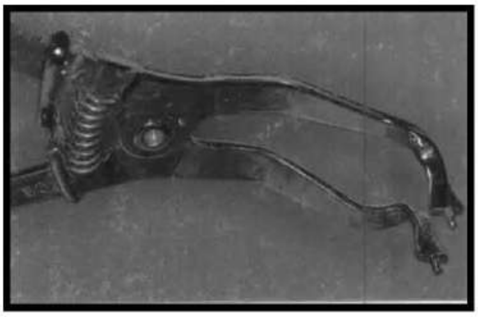
The R.D. clamp is used to grasp the tooth needed to be endodontically treated and secure the rubber dam material and frame in place. There are many types of R.D. clamps, and each one of them is placed in a different tooth or region.

Type of Clamp	Used for
Ivory No. 9	Incisors and bicuspids
Ivory No. 1	Bicuspids
Ivory No. 26	Molars
Ivory No. 0	Incisors and cuspids Multiple isolation
Ivory No. 14A	Molars (partially erupted, badly broken-down, when other clamps fail)

<u>Rubber Dam Puncture</u>

It is a n instrument used to create a hole in rubber dam. The hole should be clear without any tags or tears. The size of the hole punched or created depends on the tooth to be isolated. The puncture provides this hole to give maximum adaptation of the rubber dam around the tooth.

<u>Clamp Holder</u>

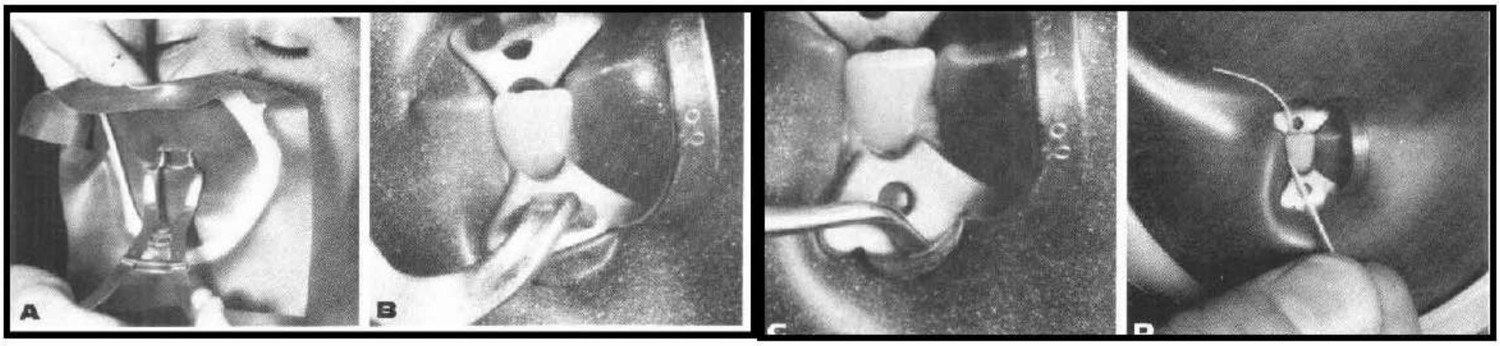


Sometimes it's called a forceps. This holder or forceps is used to place the clamp on the tooth by grasping the R.D. clamp from 2 lateral holes and widening the clamp to fit on the tooth.

<u>Methods of Applying The Rubber Dam</u>

<u>**Method 1:** Application of the clamp & rubber dam together</u>

- Select the suitable clamp to be used.
- Insert the wing in the hole after stretching the rubber dam on the frame with the forceps.
- Apply the clamp on the tooth.
- Release the wing from the dam.
- Restretch the rubber dam on the frame tightly to provide a good retraction to lips & cheek.
- Swab the isolated tooth & the adjacent dam with a suitable disinfectant .



<u>Advantages</u>

1- Easy & fast.

2- It doesn't require the aid of assistance.

3- If the clamp snaps during placement, it's held by the dam.

<u>Disadvantage</u>

1- It doesn't permit direct visualization of the tooth & soft tissues during placement.

<u>**Method 2** – Application of clamp & then dam.</u>

- Select the suitable clamp to be used.

- Place the clamp on the tooth.

- Stretch the dam on the frame.

- Draw the dam over the clamp.

Advantages

1-It allows unobstructed visualization of the tooth & surrounding tissues during clamp placement.

2- Its most efficient method of dam placement if there's difficulty in securing the clamp.

Disadvantages

1- Tearing of the dam.

2- Dislodgment of clamp during rubber dam drawing.

Method 3 – Application of dam & then the clamp.

- Select the suitable clamp to be used.

- Stretch the dam on frame.

- Apply the dam on the tooth.

- While retracting the dam to expose the tooth & the adjacent gingiva, place the clamp on the tooth.

Advantages

- There's little tendency to dislodgement of the clamp during placement.

- It provides direct visualization of the tooth & adjacent gingiva.

Disadvantage

- It needs help of assistance especially in post. teeth as the mandibular molars.

Operative Dentistry

Dr. Mohammed Ayad

Lecture (11)

Restorative Dentistry and Pulpal Health

Teeth are vital organs; they should be treated with consideration when subjected to operative procedures. The pulp responds very quickly to external stimuli, and the response depends on the severity of the stimuli. The effects of the different operative procedure on the pulp can be subdivided into:

A-Effect of Local Anesthetic on the Pulp

Vasoconstrictors of LA potentiate and prolong anesthetic effect by reducing blood flow in the area. Reduction in blood flow during a restorative procedure could lead to an increase in the concentration of irritants accumulating within the pulp.

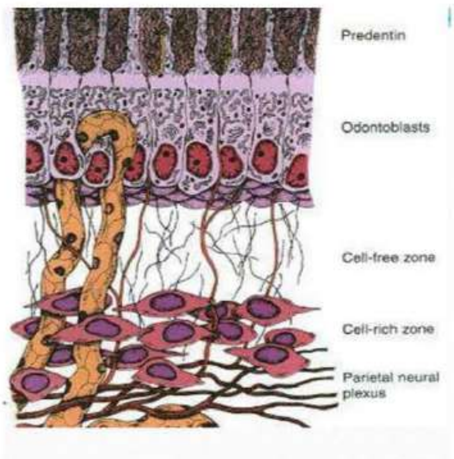
B-Effect during cavity and crown preparation (cutting procedures)

Effects of cutting procedure on the pulp can be divided into:

1- Thermal injury (frictional heat)

Despite low thermal conductivity of dentin, the heat generated by grinding procedures of tooth structure has often been considered as being the greatest single cause of damage, if high temperatures are produced in the deep cavity by continuous cutting without proper cooling, the underlying pulp may be severely damage. Excessive heat generation lead to change in dentin color due to vascular stasis and hemorrhage in sub-odontoblastic vascular plexus present in the pulp.

If the damage is extensive and the cell-rich zone of the pulp is destroyed, reparative dentin may not be formed resulting in generalized cellular degeneration and localized abscess may develop.



Basic factors in rotary instrumentation that cause a temperature rise in the pulp:

a. Force applied by the operator is directly proportional to heat generation.

b. Revolutions per minute (speed of rotation):

The development of ultra-speed (300,000 RPM) and more found to be more traumatic to the pulp than low- speed (6000 RPM) because of increase of frictional heat, but this occur in case if inadequate air water coolant is used. So, it is essential that the development of these high-speed hand pieces should be accompanied by adequate cooling mechanisms to dissipate the heat generated by grinding. Water cooling system is better than air-cooling.

The advantages of a water-cooling system are

(1) reduction of temperature rise

(2) removal of debris

(3) clean vision

c. Size, shape and the condition of cutting tools:

Tungsten carbide much harder than stainless -steel, once the bur dull, there is a decrease in cutting efficiencies and an increase in heat and vibration.

Diamond bur has a full surface contact with the tooth surface so is more heat generation. Bur with longitudinal serration or with a crosscut its better because water can get to the cutting blades easily and this will reduce the heat generation.

d. Duration of actual cutting time:

Intermittent cutting at intervals of a few seconds can reduce the heat generation compared to continuous cutting.

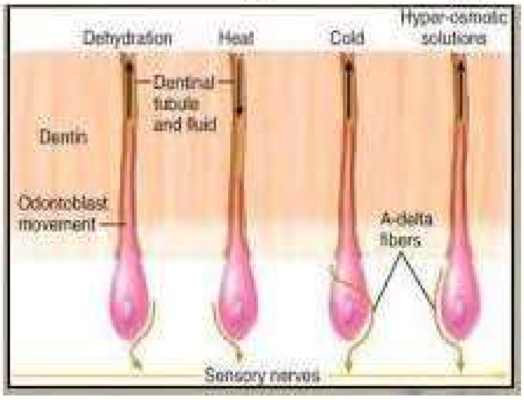
The heat of polishing: the pulp damage caused by polishing the restorations must be considered, especially if we use dry powder. Polishing burs made of rubber created higher temperatures than cup brushes. Continuous polishing using high speed of rotation is associated with greater heat production than intermittent polishing with low speed. This procedure can be considered as a source of thermal irritation during restorative procedures.

2- Amputation of the odontoblastic processes

Amputation of the distal segment of odontoblast processes is a consequence of cavity preparation, but this quickly followed by repair of the cell membrane. While if the amputation of the odontoblast process occurs close to the cell body, this will lead to irreversible injury. Also, during cutting procedure there is a disturbs of tight junction between adjacent odontoblasts, thus increasing the permeability of the odontoblast layer and could increase the potential for entry of toxic substances into the subjacent pulp tissue. It has been confirmed that after cavity preparation in rat molars, Apoptosis (the death of cells) of odontoblast occurs, this may indicate a greater impact of surgical phase on the pulpal damage during a restoration in comparison to that of the restorative materials. In humans, postoperatively, the main reparative response of odontoblast to a cavity is the secretion of reactionary dentine.

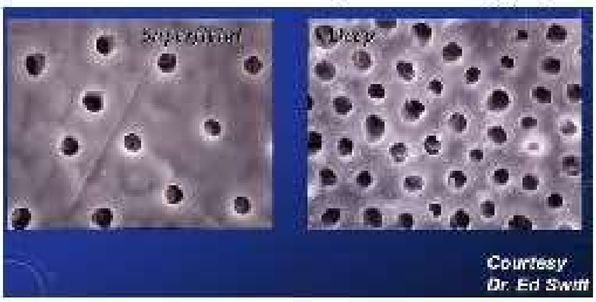
3-Dehydration

When the surface of freshly cut dentin is dried with a jet of air there is a rapid outward movement of fluid through the dentinal tubules. According to the theory of dentin sensitivity, this movement results in stimulation of the sensory nerve of the pulp and drawing odontoblasts up into tubules, these displaced odontoblasts soon die and disappear as they undergo autolysis and result in an inflammatory response. The destroyed odontoblasts replaced by new odontoblast like cells arise from the cell rich zone of the pulp and within 1-3 months reparative dentin formed.



4-Remaining dentin thickness (RDT)

Dentin permeability increases with increasing cavity depth due to the differences in size and number of dentinal tubules. The permeability of dentin is of great importance in determining the degree of pulp injury resulting from the restorative procedures and materials. The distance between the floor of the cavity preparation and the pulp greatly influences the pulpal response to operative procedures and materials. Conservation of the remaining tooth structure is more important to pulpal health than is the replacement of lost tooth structure with cavity liner and base. Also, it has been noted that there is an inverse relationship between the remaining dentine thickness and pulp injury and repair.



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5-Pulpal exposure

Exposure of the pulp during cavity preparation occurs in the process of removing carious dentin. Accidental mechanical exposure may result during the placement of pins or retention points in dentin (large pulp chamber, extensive pulp horn even with a shallow cavity). Injury to the pulp appears to be due to the bacterial contamination, so carious exposure results in much more bacterial contamination than does accidental exposure, therefore treatment prognosis is poor with carious exposure. Occasionally a pulp exposure is made unknown to the dentist because there is no bleeding. The first indication of a problem is the patient complaint of pulpal pain when the anesthesia wears off. Treatment of pulpal exposed teeth compared to non-exposed teeth is more challenging in terms of hemorrhage control, identifying and removing infected tissue and loss of dentine barrier, which can maximize adverse effects of pulp capping materials on the pulp.

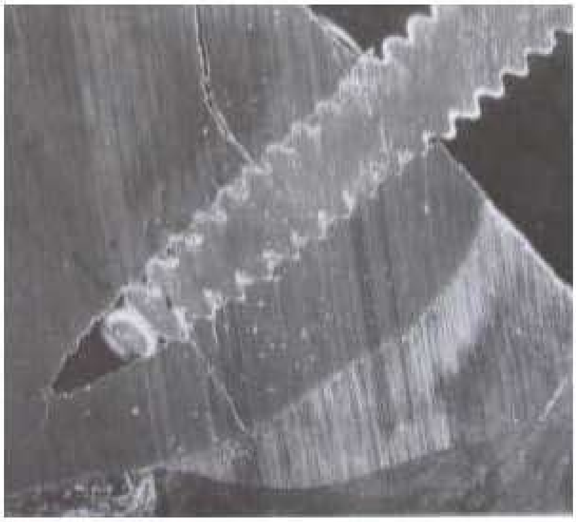
6-Pin insertion

Since the advantages of pin placement into dentin is to support amalgam and composite restoration or as a framework for building up vital badly broken teeth for full crown construction, increase in pulp inflammation and death has been noted. Pin insertion result in

-Heat generation and this will increase the incidence of pulp damage.

-Pins may have been inadvertently inserted directly into the pulp or so close to it that they acted as a severe irritant.

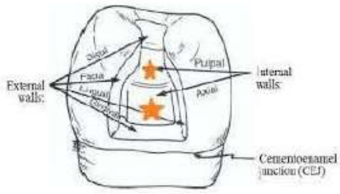
-Craze and stress in dentin during insertion.



C-Effect of lining materials and procedure

- Zinc phosphate cement: the initial cement mixture is highly acidic because of phosphoric acid, although the PH approaches neutrality in a short period of time, newly mixed phosphate cement is highly irritant to the pulp and produce irreversible pulpal damage. (acidity will decrease the blood flow and cause pulpal death).
- Zinc Polycarboxylate cement is less irritant than Zinc phosphate cement, the lower level of irritation may be due to the large molecular size of polyacrylic acid molecules which restricts penetration through dentin and adapted well to dentin and has a bacteriocidal effect.

- Zinc Oxide Eugenol has a palliative effect, PH (7), bacteriostatic and bactericidal, has a good marginal seal. Eugenol, a phenol derivative, is known to be toxic, its capable of producing thrombosis of blood vessels when applied directly to pulp tissue. Because eugenol injures cells, there is a question whether should be used in very deep cavity preparation where there is a risk of pulp exposure.
- Glass ionomer cement: it has been found that GIC has no irritating effect upon living pulp.



-Lining materials should not place on the wall and margins because it dissolves in oral fluid leaving a wide gap between the restoration and tooth and this consider as a source of an irritant.

-The thickness of base materials should be (1-2mm) is an effective barrier against both hot and cold stimuli in a deep cavity.

-Force of cementation: the patient complains of pulp pain when an inlay or crown is finally cemented with ZPC due to chemical irritation of the cement liquid as a factor. But on the other hand, the hydraulic pressure exerted during cementation could not help but drive the fluid toward the pulp that results in separation of the odontoblast layer from the dentin and cause irritation to the pulp.

D-Effect of filling materials and procedure

In resin restoration, the initial toxic shock is so severe, that extensive use of mouth curing plastic as filling and temporary crown might be related to a great number of pulp death.

Composite resins and bonding agents: Resin composites and bonding resin can also cause marked inflammation, damage to the pulp and dilatation and congestion of blood vessels when placed in deep dentin. In fact, compounds such as triethylene glycol dimethacrylate (TEGDMA) and camphoroquinone, 2-hydroxyethyl methacrylate (HEMA) components, which diffuse from bonding resins and resin composites through dentine into the pulpal tissue in small quantities (micrograms) within hours and days after placement, can cause adverse cytotoxic effects on the pulp. The release of unreacted monomer (1.5-5% of the methacrylic group remain unreacted) is because of mechanical, thermal and chemical factors that inhibit complete polymerization, which is enough to initiate a cytotoxic effect.

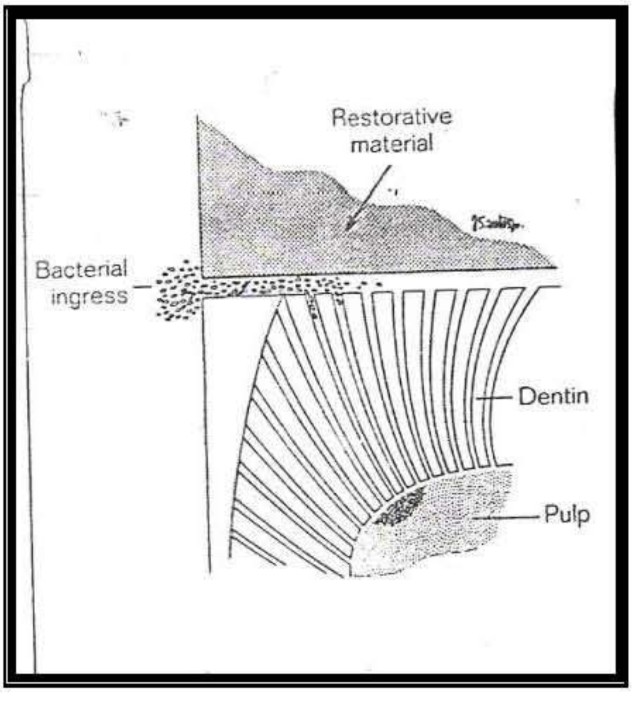
Acid etching: there is no significant effect of the acid on the pulpal microvascular vessels. But the acid etching widens the opening of dentinal tubules that increase the dentin permeability, and enhance bacterial penetration of dentin.

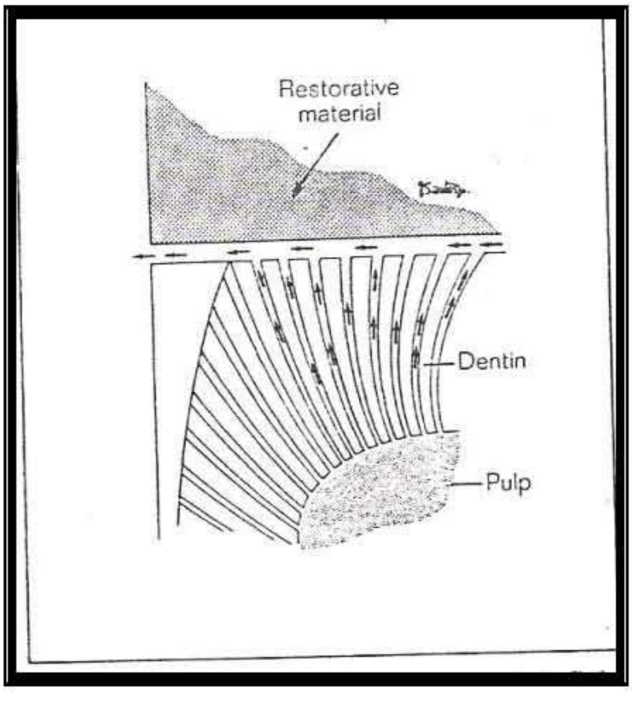
Dental amalgam: Ions such as silver, copper, and mercury, which are released from amalgam, may have an adverse effect on the pulpal tissue by diffusion through dentinal tubules beneath restorations. Because of the unreacted mercury, freshly mixed amalgam is more cytotoxic than set amalgam. Mercury compounds exhibited higher cytotoxicity compared to the resin composite constituents because of the ability of the mercury compounds to interfere with the cellular metabolism and function leading to cell swelling and finally cell death.

Patient, sometime report hypersensitivity following insertion of dental amalgam and this may be related to 1-force of insertion 2-possibility to the expansion of amalgam after insertion.

The pulp may be injured from severe temperature changes induced by thermal energy passing through the metallic restoration. Thus, wherever the cavity preparation is deep and inadequate thickness of dentin is present for thermal isolation, protection by a cement base must be provided.

No permanent filling material has been shown to provide a perfect marginal seal. So, leakage and bacterial contamination are always a threat to the integrity of the pulp.





Bacteria growing beneath restoration will produce toxic products that diffuse through the dentinal tubules and cause inflammatory reactions. adequate liner or cement base should be employed to seal the dentinal tubules before inserting restorative materials, and it's better that these cements have the ability to inhibit bacterial growth (e.g. ZOE, GIC).

Two important factors affecting marginal adaptation: 1-temperature changes, 2-masticatory forces. If a material has a different coefficient of thermal expansion than tooth structure, the temperature change is likely to produce gaps between the material and the cavity. In composite filling, the marginal seal has been improved by acid etching of beveled enamel and the use of the bonding agent or primer. But it has been shown that the initial marginal seal tends to decrease as the etched composite restoration ages.

E-Accumulative effect is the whole irritation that the tooth is subjected to during all this time (carious process, cavity preparation, lining and filling procedure, secondary caries) so the pulp in a continuous process of irritation and inflammation. If there is a small inflammatory process it may be getting worse till the whole pulp involved and become necrotic. This may occur very fast or slowly depending on the severity of irritation, and this may occur without any discomfort to the patient.
Many operative insults can be minimized considerably during routine operative procedures:

- Depth, width and extension of the cavity preparation
- Heat and desiccation damage during cavity preparation
- Chemical injury through use of medicaments (e.g. acid etchants, …etc.)
- Toxicity of liners, bases and filling materials
- Prevention of microleakage

Dr. Mohammed Ayad

Operative Dentistry

Lecture (12)

Management of Deep-Seated Carious lesions

Introduction

Dental pulp is a highly vascularized tissue of the tooth and has the potential to heal. It performs many functions throughout the life of tooth therefore, every effort should be made to maintain its integrity and vitality. In asymptomatic, vital teeth with deep lesions, strategies for conservative carious tissue removal which reduce tissue loss and pulp exposure risk have to be balanced against removing adequate tissue to maximize restoration longevity. The criterion used to guide carious dentin tissue removal is hardness, judged by tactile feedback during examination.

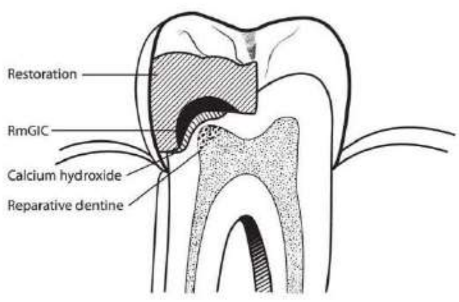
Vital Pulp Therapy for Teeth Diagnosed with a Normal Pulp or Reversible Pulpitis

I-Protective liner:

A protective liner is a material placed on the pulpal surface of a cavity preparation, covering exposed dentin tubules, to act as a protective barrier between the restorative material or cement and the tooth's pulp. Placement of a liner and a protective base such as calcium hydroxide and glass ionomer cement are frequently used.

Indications: In a tooth with a normal pulp, when dentin is exposed and all caries is removed during the preparation for a restoration, a protective radiopaque liner may be placed between the permanent restoration and the dentin to minimize thermal and chemical pulp injury, promote pulp tissue healing and induce reactionary dentin formation, or minimize postoperative sensitivity.

Objectives: A protective liner is utilized to preserve the tooth's vitality, promote pulp tissue healing and tertiary dentin formation, and minimize microleakage. Adverse post-treatment signs or symptoms such as sensitivity, pain, or swelling should not occur.



مخالفة الهوى تقيم العبد في مقام من لو اقسم على الله لابره، فيقضي له من الحوائج اضعاف اضعاف ما فاته من هواه.

II- Indirect Pulp Capping

Sir John Tomes stated in 1859 that 'It is better that a layer of discolored dentine be allowed to remain for the protection of the pulp rather than run the risk of sacrificing the tooth.' He had observed that discolored and demineralised dentine could be left behind in deep cavities of the tooth before restoration, often with highly satisfactory results. To achieve indirect pulp protection, carious dentine near the pulp is preserved in order to avoid pulp exposure and is covered with a suitable material. This is especially applicable if exposures of the pulp are suspected in teeth with deep carious lesions, where the carious lesion extending to ¾ of dentin thickness on the radiogragh. The removal of this dentine may lead to exposure of the pulp, thus impairing its prognosis.

It has been shown that demineralised dentine, if it is free of bacteria, will remineralise once the source of the infection has been eliminated. The diagnosis of the presence of demineralised dentin that is bacteria-free can be assisted by using a caries disclosing solution. However, it has been shown that using these disclosing solutions may stain deep dentin layer close to the pulp resulting in over excavation. The placement of a suitable material directly on this demineralised dentin is commonly called indirect pulp capping (IPC) or indirect pulp protection.

Methods of carious tissue removal to perform IPC procedure:

The step of partial removal of carious dentine, leaving bacteria-free demineralized dentine is called selective carious tissue removal. Studies found that the selective removal of the heavily infected dentine biomass while retaining affected dentine, shows favorable results in terms of tooth vitality preservation. Selective carious tissue removal can be performed either by incomplete caries removal with no subsequent re-entry (one visit) or stepwise caries removal with subsequent re-entry (two visits). Both techniques resulted in fewer numbers of pulp exposure. The difference between them is that in the one step incomplete caries removal, there is no subsequent reopening of the cavity after 3-6 months. In stepwise caries removal, there is a second entry to the cavity to remove the remaining soft affected dentine completely.

Material used for IPC

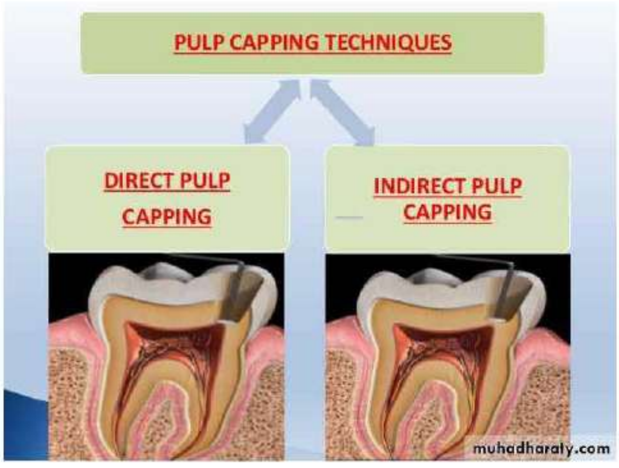
1) This can be achieved with the placement of an antibacterial liner such as calcium hydroxide, MTA, Biodentine, or zinc oxide–eugenol cement, which is aimed at stimulating secondary dentine formation.
2) With the advent of adhesive dental materials, another possible restorative option is the placement of calcium hydroxide, MTA, Biodentine followed by an adhesive base such as glass–ionomer or resin modified glass–ionomer cement. The aim is to provide a combination of an antibacterial barrier and an adhesive seal against the further ingress of bacteria.

Indication of IPC:

1) When there is a radiographically evident deep carious lesion encroaching on the pulp.
2) Tooth has no history of spontaneous pain.
3) Tooth responds normally to vitality test.

Procedure of stepwise carious tissue excavation and IPC:

1. Field must be isolated with rubber dam isolation to minimize bacterial contamination of the treatment site.
2. All peripheral carious dentin is removed with large round bur or spoon excavator.
3. Area adjacent to the pulp is debrided off only the soft carious dentin.
4. CaOH2 and ZOE — type liners Placed.
5. Base or adhesive cement applied over the lining for complete sealing
6. After 3-6 months or more Cement removed.
7. Internal surface of the cavity inspected for remineralization and hard dentin formation.
8. Remove any residual soft dentin.
9. Permanent restoration applied.



III- Direct Pulp Capping

Direct pulp capping can be described as the dressing of an exposed pulp with the objective of maintaining pulp vitality.

Indications

Indications for pulp capping include

1. Teeth with recent (24 h) traumatic exposures or mechanical non-carious exposures during cavity preparation.
2. Pulp capping should be considered only for immature permanent teeth, or for mature permanent teeth with simple restorative needs.
3. Mature teeth with inflamed pulps, as with carious pulp exposures, should not be pulp capped.
4. Pre-operative tooth sensitivity frequently has been mentioned as a contraindication to Pulp capping.

Requirements for a successful direct pulp therapy

Direct pulp therapy has a high success rate if the following conditions are met:

(1) The pulp is not inflamed; i.e. signs and symptoms not of irreversible pulpitis.

(2) Hemorrhage is properly controlled; Various methods have been proposed to achieve pulpal hemostasis, including mechanical pressure with a sterile dry cotton pellet, or with one soaked in saline, hydrogen peroxide, sodium hypochlorite, in concentrations of 2.5%, 3%, or 5.25%, is a biocompatible and effective solution for achieving hemostasis before pulp capping and the disinfectant chlorhexidine also has been described as an effective hemostatic for pulp capping

(3) A non-toxic capping material is applied; traditionally, calcium hydroxide has been the most common direct pulp-capping agent. Calcium hydroxide is antibacterial and disinfects the superficial pulp. MTA and Biodentine can be used for direct pup capping.

A major disadvantage of calcium hydroxide materials

1. They do not seal the exposed pulp from the external environment. Therefore, an additional base material, such as a resin-modified glass ionomer, can be placed to help seal the pulp against bacterial ingress during the healing phase.
2. Dentin bridges beneath calcium hydroxide pulp caps contain 'tunnel defects' that leave the pulp open to recurring bacterial infection via microleakage. In comparison to MTA, which help to form dentin bridge that is free of tunnel defects.
3. Calcium hydroxide materials tend to soften, disintegrate, and dissolve over time, leaving voids and other potential pathways for bacterial infiltration.

MTA is a dimensionally stable material that don't dissolve and can provide good barrier against ingress of fluids and bacteria. However, various other materials, including zinc oxide eugenol, glass ionomers, resin adhesives have been proposed as capping agents for vital pulp therapy, but MTA is an alkaline material that stimulates dentinal bridging and appears to have particular promise as a pulp-capping material.

Technique

1. After adequate anesthesia has been obtained, place a rubber dam and disinfect the tooth with a chlorhexidine solution and gently rinse with anesthetic or sterile saline. If any hemorrhage occurs, dab with a sterile cotton pellet until hemorrhage ceases. As noted previously, a sodium hypochlorite or chlorhexidine solution may be used to aid in hemostasis.
2. Mix pure calcium hydroxide with sterile water, saline, or anesthetic solution, and apply directly to the exposure site. A hard-setting calcium hydroxide liner also can be used, and is preferable if the pulp is small.
3. Next, apply and light-cure a resin modified glass ionomer base/liner material such as to protect the calcium hydroxide dressing and to provide a better seal.
4. Finally, use a good temporary and wait for 4 - 6 weeks for final restoration.

Recall

The tooth should be evaluated using electrical pulp testing (EPT), thermal testing, and palpation and percussion tests at 3–4 weeks, 3 months, 6 months, 12 months, and every year thereafter. Periodic radiographs are needed to detect the presence of periapical radiolucencies, and for immature teeth, continued development of the root. Hard tissue barriers sometimes can be seen at the treated exposure site as early as 6 weeks after treatment.

Prognosis

The success of the pulp-capping procedure relies on the ability of calcium hydroxide to disinfect the superficial pulp and dentin and to initiate necrosis of the superficial inflamed pulp. The quality of the bacteria-tight seal provided by the base, bonding system, and restoration is also of critical importance. The reported prognosis for direct pulp capping is in the range of 80% when performed under ideal conditions, that is, on an uninflamed pulp and with a good coronal seal.

IV- Partial pulpotomy

The phrase 'partial pulpotomy' or 'Cvek pulpotomy' describes removal of inflamed pulp tissue to the level of healthy coronal pulp. A sterile diamond rotating at high speed under copious water spray is used to surgically excise inflamed pulp tissue. The excision is considered complete when the pulp stump no longer bleeds excessively. The rationale for the Cvek pulpotomy is this: if the inflamed tissue is removed, the healthy underlying tissue is more likely to remain healthy and to seal the exposure with hard tissue bridging of the exposure site. Of course, the other requirements for successful pulp capping, such as hemostasis and a bacteria-tight seal, are met. Pulpotomies have been used routinely in treatment of primary and young permanent teeth after traumatic pulp exposures, but their use in mature permanent teeth is a relatively new concept, and is considered unproven for carious exposures.

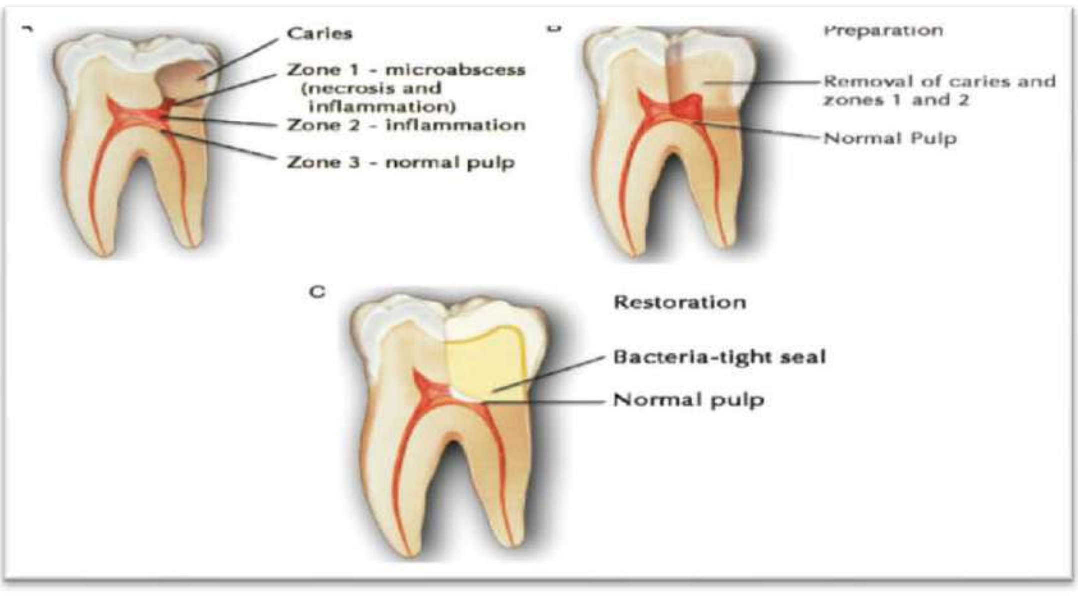
Indications

Indications for a partial pulpotomy are similar to those for direct pulp capping. As with simple direct pulp capping, an immature permanent tooth or a mature permanent tooth with uncomplicated restorative needs is preferable. The partial pulpotomy should be selected as an alternative to direct pulp capping when the extent of pulpal inflammation is expected to be greater than normal.

Technique

Accomplish anesthesia, isolation, and surface disinfection is described in the section on direct pulp capping.

At the exposure site, remove 1–2mm of the superficial pulp tissue using a sharp, sterile diamond rotary instrument. The diamond should be running at very high speed with copious water spray.



If excessive bleeding continues, extend the preparation apically. Remove any excess blood by rinsing with sterile saline or anesthetic solution and dry with a sterile cotton pellet. If the pulp tissue show optimal condition (vascular non bleeding tissue), then stop cutting of pulp tissue.

As described previously, sodium hypochlorite or chlorhexidine can be used to facilitate hemostasis. Take care to avoid formation of a blood clot, which compromises the prognosis.

Mix and apply a thin layer of pure calcium hydroxide. If the pulp is not large enough to accommodate any further loss of tissue, mix and apply a hard-setting calcium hydroxide liner such as Dycal.

As in teeth with conventional direct pulp caps, place an appropriate resin-modified glass-ionomer liner or base, a dentin/ enamel adhesive, and restorative material.

Recall

Schedule follow-up examinations, using the time intervals and procedures described for pulp capping.

Prognosis

The partial pulpotomy offers several advantages over direct pulp capping.

a) Superficial inflamed pulp tissue is removed during preparation of the pulpal cavity.
b) Calcium hydroxide disinfects the pulp and dentin and removes additional inflamed pulp tissue.
c) In addition, the pulpotomy provides space for the materials required to provide the requisite bacteria-tight seal.

The prognosis for success of partial pulpotomies is in the range of 95%. However, this success rate is for traumatized teeth where the level of pulpal inflammation is very predictable. The success rate for treatment of carious exposures is unknown currently.

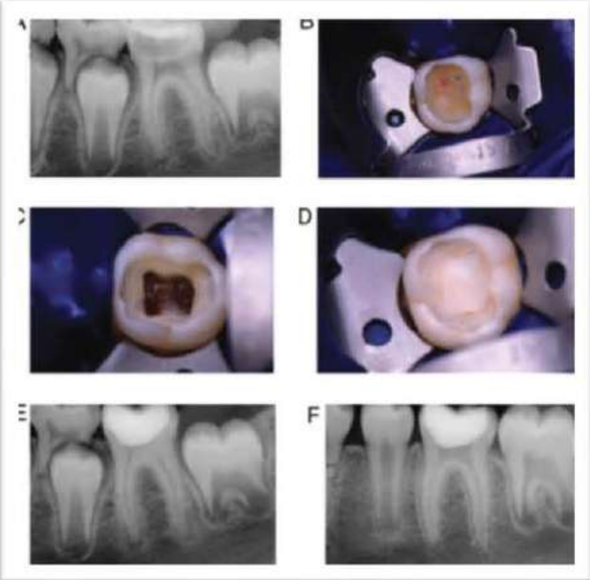
V- Full pulpotomy

A 'full pulpotomy' involves removal of the entire coronal pulp to the level of the root canal orifice(s).

Indications

The indications for a full pulpotomy are similar to those for a partial pulpotomy, except that the pulp in question is likely to have more extensive inflammation, if the coronal pulp is rather small in size.

Technique



a) The technique for a full pulpotomy is similar to that of the partial pulpotomy, except that the entire mass of coronal pulp tissue is removed, normally to the canal orifices.
b) The tissue is capped with calcium hydroxide in a manner similar to partial pulpotomy.

Recall

Recall evaluations are performed at the same intervals recommended for a tooth treated with a direct pulp cap or partial pulpotomy.

Posterior Composite Restoration

INTRODUCTION

Esthetic dentistry has shown much advancement in materials and technology since the last century.

The history of tooth colored restorative materials started with silicate cement in the year 1878 in England followed by self-curing acrylic resins which were developed in 1930 in Germany. Both of these materials showed poor physical properties like high polymerization shrinkage and coefficient of thermal expansion, lack of wear resistance, poor marginal seal, irritation to pulp and dimensional instability.

Bowen, in 1962 developed a polymeric dental restorative material reinforced with silica particles used as fillers. These materials were called 'composites'.

Composite is a compound composed of at least two different materials with properties that are superior or intermediate to those of an individual component.

Over the past two decades, there has been a substantial progress in the development and application of resin-based composites. Earlier composites were recommended only as a restorative material for anterior restorations, but now they have become one of the most commonly used direct restorative materials for both anterior and posterior teeth. Principal reasons for shifting from dental amalgam to composites are reduced need for preparation and strengthening effect on remaining tooth. Nowadays, composite resins are considered as an economical and esthetic alternative to other direct and indirect restorative materials.

COMPOSITION OF DENTAL COMPOSITES

1. Organic Matrix

Resin matrix represents the backbone of composite resin system. Most preferred monomers are Bis-GMA, Urethane dimethacrylate UDMA, or combination of them. Since these resins are very viscous, and in order to improve handling and to control viscosity, they are diluted with low viscosity monomers like triethylene glycol dimethacrylate (TEGDMA).

2. Fillers

Commonly used inorganic fillers are silicon dioxide, boron silicates and lithium aluminum silicates. In some composites, quartz is partly replaced with heavy metal particles like zinc, aluminum, barium, strontium or zirconium. Nowadays calcium metaphosphate is also used because it is softer than glass, so cause less wear of opposing tooth. Filler content ranges from 30% to 50% by volume and 50% to 85% by weight.

Advantages

1. Reduces the coefficient of thermal expansion
2. Reduces polymerization shrinkage
3. Increases abrasion resistance
4. Decreases water sorption
5. Increases tensile and compressive strengths
6. Increases fracture toughness
7. Increases flexure modulus
8. Provides radiopacity
9. Improves handling properties
10. Increases translucency

3. Coupling Agents: Coupling agent binds the hydrophilic filler particles to the hydrophobic organic resin. Interfacial bonding between the matrix phase and the filler phase is provided by coating the filler particles with silane coupling agents.

4. Initiator Agents: These agents activate the polymerization of composites. Most common photoinitiator used is camphorquinone. Currently most recent composites are polymerized by exposure to visible light in the range of 410 to 500 nm. Initiator varies with type of composites whether it is light cured or chemically cured.

5. Inhibitors:These agents inhibit the free radical generated by spontaneous polymerization of the monomers. For example, butylated hydroxyl toluene (0.01%).

6. Coloring Agents:Coloring agents are used in very small percentage to produce different shades of composites. Mostly metal oxides such as titanium oxide and aluminum oxides are added to improve opacity of composite resins.

7. Ultraviolet Absorbers: They are added to prevent discoloration, in other words they act like a "sunscreen" to composites. Commonly used UV absorber is benzophenone.

TYPES OF COMPOSITES

1. Macrofilled Composite

These were developed during early 1970s. Average particle size of macrofill composite resins ranges from 8–12 um. Filler content is approximately 60–65% by weight. It exhibits a rough surface texture because of the relatively large size and extreme hardness of the filler particles. Due to roughness, discoloration and wearing of occlusal contact areas and plaque accumulation take place quickly than other types of composites.

Advantage: Physical and mechanical performance is better than unfilled acrylic resins.

Disadvantages: Rough surface finish, Poor polishability,More wear.

2. Microfilled Composites Resins

These composites were introduced in the early 1980s. Average particle size ranges from 0.04 to 0.4 micrometer. Filler content is 30 to 40% by weight. Small particle size results in smooth polished surface which is resistant to plaque, debris and stains. But because of less filler content, physical properties are inferior. They are indicated for the restoration of anterior teeth and cervical lesions.

Advantages Highly polishable, Good esthetic.

Disadvantages

- Poor mechanical properties due to more matrix content
- Poor color stability
- Low wear resistance
- Less modulus of elasticity and tensile strength
- More water absorption
- High coefficient of thermal expansion.

3. Hybrid Composite Resins

Hybrid composites are composed of glasses of different compositions and sizes, with particle size diameter of less than 2 μm and containing 0.04 μm sized fumed silica. This mixture of fillers is responsible for their physical properties similar to those of conventional composites with the advantage of smooth surface texture.

Disadvantages: Not appropriate for heavy stress bearing areas , and oss of gloss occurs when exposed to toothbrushing with abrasive toothpaste.

4. Microhybrid, Nanohybrid, and Nanofill

Microhybrid composites have evolved from traditional hybrid composites. Filler content in microhybrids are 56 to 66% by volume with average particle size of 0.4 to 0.8 µm. Incorporation of smaller particles make them better to polish and handle than their hybrid counterparts.

Nanofill and nanohybrid composites have average particle size less than that of microfilled composites. Use of these extremely small fillers and their proper arrangement within the matrix results in physical properties equivalent to the original hybrid composite resins.

Advantages

Highly polishable

Tooth-like translucency with excellent esthetic

Optimal mechanical properties

Good handling characteristics.

Good color stability

Stain resistance

High wear resistance

Can be used for both anterior and posterior restorations and for splinting teeth with fiber ribbons.

Flowable Composite Resin

Flowable composites were introduced in dentistry in late 1996. Filler content is 60% by weight with particle size ranging from 0.02 to 0.05 µm. Low filler loading is responsible for decreased viscosity of composites, which allows them to be injected into small preparations,

Condensable (Packable) Composites

Condensable/packable composites have improved mechanical properties and handling characteristics. Main basis of packable composites is Polymer Rigid Inorganic Matrix Material (PRIMM). Here components are resin and ceramic inorganic fillers which are incorporated in silanated network of ceramic fibers. These fibers are composed of alumina and silicon dioxide which are fused to each other at specific sites to form a continuous network of small compartments.

Filler content in packable composites ranges from 48 to 65% by volume with average particle size ranging from 0.7 to 20 μm.

PROPERTIES OF COMPOSITE

Coefficient of Thermal Expansion

Coefficient of thermal expansion of composites is approximately three times higher than normal tooth structure. This results in more contraction and expansion than enamel and dentin when there are temperature changes resulting in loosening of the restoration. It can be reduced by adding more filler content.

Wear resistance

Composites are prone to wear under masticatory forces, toothbrushing and abrasive food. Site of restorations in dental arch and occlusal contact relationship, size, shape and content of filler particles affect the wear resistance of the composites.

Polymerization Shrinkage

Composite materials shrink while curing which can result in formation of a gap between resin-based composite and the preparation wall. It accounts for 1.67 to 5.68 percent of the total volume.

Configuration or C-factor

Cavity configuration or C-factor was introduced by Professer Carol Davidson and his colleagues in 1980s. C-factor is the ratio of bonded surface of restoration to unbonded surfaces. Higher the value of 'C'-factor, greater is the polymerization shrinkage. THree-dimensional tooth preparations (Class I and V) have the highest (most unfavorable) C-factor and thus are at more risk to the effects of polymerization shrinkage. C-factor plays a significant role when tooth preparation extends up to the root surface causing a 'V' shaped gap formation between the composite and root surface due to polymerization shrinkage.

Microleakage

It is passage of fluid and bacteria in micro-gaps (10–6 m) between restoration and tooth. It can result in damage to the pulp.

Microleakage can occur due to: 1) Polymerization shrinkage of composites, 2) Poor adhesion and wetting, and 3) Thermal stresses Mechanical loading

Microleakage results in: 1) Bacterial leakage , 2) Recurrent caries, 3)Pulpal infection, and 4)Tooth discoloration.

ADVANTAGES

1. Conservation of tooth structure.
2. Esthetically acceptable
3. Low thermal conductivity: Composites have low thermal conductivity, thus no insulation base is required to protect underlying pulp.
4. Mechanical bonding to tooth structure: Restorations are bonded with enamel and dentin, hence show good retention.
5. Immediate finishing and polishing: Restoration with composite resins can be finished immediately after curing.
6. It can be repaired rather than replaced.
7. Restoration can be completed in one dental visit.
8. No galvanism because composite resins do not contain any metals.

DISADVANTAGES

1. Polymerization shrinkage.
2. Time consuming: Composites restorations require good isolation and number of steps for their placement.
3. Composites restorations are more difficult to place and are Time consuming.
4. Expensive: more expensive than amalgam.
5. Technique sensitive: It is more technique sensitive than amalgam because composite placement requires careful attention to all steps of placements.
6. Low wear resistance: Composites have low wear resistance than amalgam.

TOOTH PREPARATION

GENERAL CONCEPTS FOR TOOTH PREPARATION FOR COMPOSITE RESTORATIONS:

1. Conservation of tooth structure: Tooth preparation is limited to extent of the defect. For composite restorations, rule extension for prevention and proximal contact clearance, is not necessary unless it is required to facilitate proximal matrix placement.

2. Variable depth of pulpal and axial wall depth: Pulpal and axial walls need not to be flat.

3. Preparation of operating site: To facilitate bonding, tooth surface is made rough by using diamond abrasives.

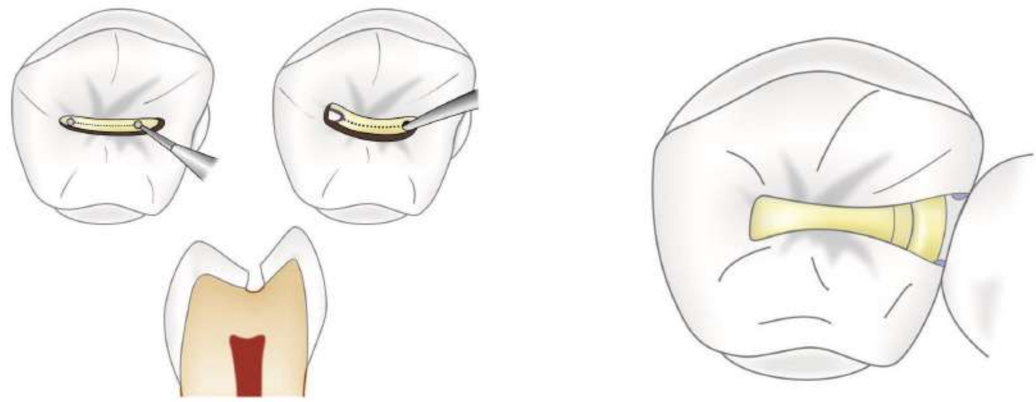
4. Enamel bevel: Enamel bevel is given in some cases to increase the surface area for etching and bonding.

5. Butt joint on root surface: Cavosurface present on root surfaces has to be butt joint.

Designs of Tooth Preparation for Composites

1. Conventional preparation

Conventional design is similar to the tooth preparation for amalgam restoration, except that there is less outline extension and in tooth preparation, walls are made rough. Indicated in moderate to large class I or class II restorations and in preparations located on root surface.

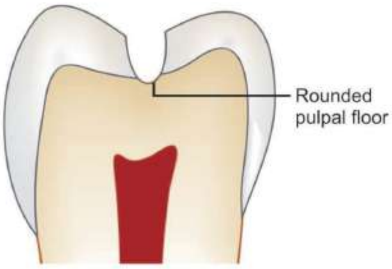


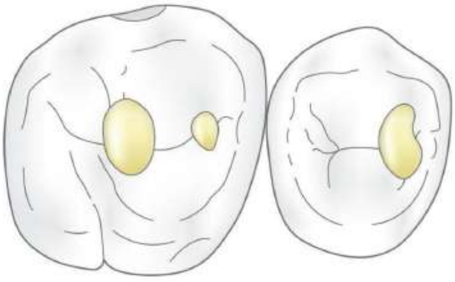
2. Beveled conventional tooth preparation

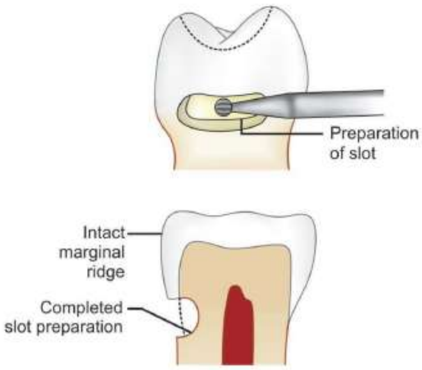
This design is almost similar to conventional design but some beveled enamel margins are incorporated. Specially indicated for classes III, IV, V and VI restorations.

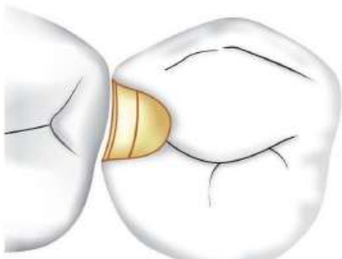
3. Modified (conservative tooth preparation)

It is more conservative in nature since retention is achieved by micromechanical bonding to the tooth. It does not have specified wall configuration or pulpal and axial wall depth. Extent and depth of the preparation depends upon the extent and the depth of carious lesion. Indicated for initial or small carious lesions.





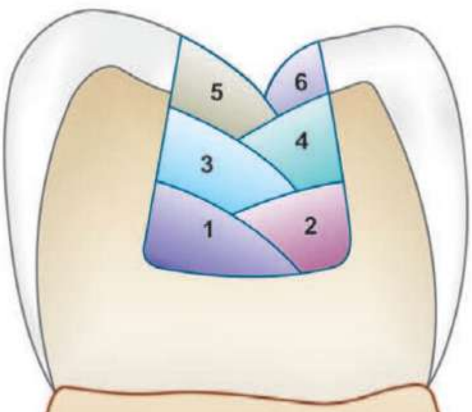




COMPOSITE PLACEMENT

Incremental Layering Technique

- Advocated for use in medium to large posterior composite restorations to avoid the limitation of depth of cure
- This technique is based on polymerization of resin-based composite layers of less than 2 mm thickness
- It helps to attain good marginal quality
- It prevents deformation of the preparation wall
- It ensures complete polymerization of the resin-based composite
- Incremental layering of dentin and enamel composite creates layers with high diffusion which allows optimal light transmission within the restoration, thus increasing esthetics.



Bulk Technique

- The composite is placed in a bulk mass of 4-5 mm thickness.
- It is done to reduce stress at the cavosurface margins.
- It is usually recommended with packable composites.

Final Contouring, Finishing and Polishing of Composite Restorations

For composite restorations, the amount of contouring required after final curing can be minimized by careful placement technique. Always take care to remove the some composite excess which is almost always present. Decreased need of contouring of the cured composite ensures that margins and surface of composite restoration remain sealed and free of microcracks that can be formed while contouring.

Main objectives are to:

- Attain optimal contour
- Remove excess composite material
- Polish the surface and margins of the composite restoration.

For removal of composite excess, usually burs and diamonds are used. Surgical blade is used to remove proximal overhangs in the accessible area. For areas which have poor accessibility, composite strips can be used. Contact areas may be finished by using a series of abrasive finishing strips threaded below the contact point so as not to destroy the contact point.

Dental Laser

Dr. Mohammed Ayad

Lecture (14)

Laser: is an acronym standing for light amplification by stimulated emission of radiation. A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation.

Laser apparatus:

All lasers apparatus have similar fundamental elements which are:

A. Lasing media (active media).

B. An optical resonators.

C. An energy source.

A-Lasing media (active media):

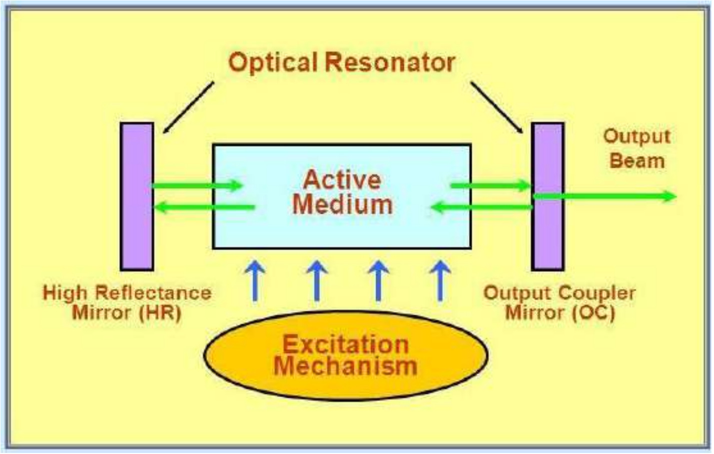
The active media may be in the form of a gas, sold, atoms or ions. Most Lasers are named with regard to the substance of active media that is used to create the actual laser light. (Ex. CO_2 laser has lasing media containing CO_2 gas).

B. Optical resonators:

The optical resonator is essentially an arrangement _of two mirrors. Basically it is consist of fully reflective mirror at one end of lasing media and partially reflective mirror at the other end of lasing media.

C. Energy source.

The atoms or molecules of the lasing media need to be excited so that photons of laser light are emitted. The energy for this excitation may be provided by electric discharge, high power xenon flash lamps or even another laser.

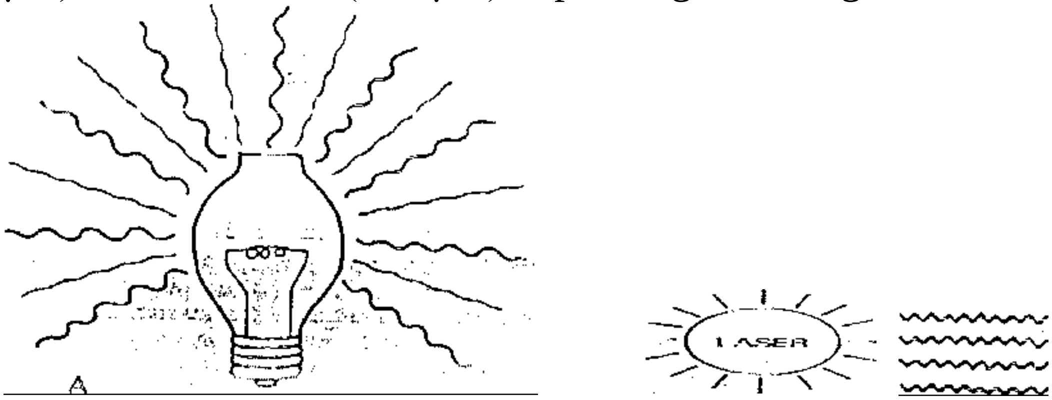


Properties of laser light:

There are several important properties of laser light that distinguish it from white(ordinary) light. These singular properties of laser light that make it useful in medicine and dental uses are :

1-Monochromaticity:

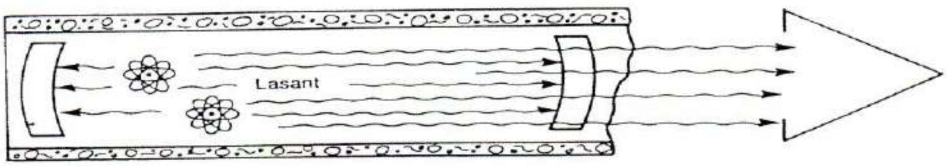
The laser light produced by particular laser device will be of characteristic wavelength, if the light produced is in the visible spectrum (0.385-0.760 μm) it will be seen as a beam of intense color. However, dental lasers can produce light from the ultraviolet (0.193 μm) to the infrared (10.6μm) depending on lasing media.

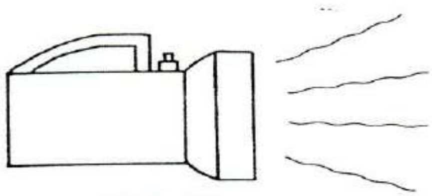


A. ordinary light **B. Laser light**

2.Directionally:

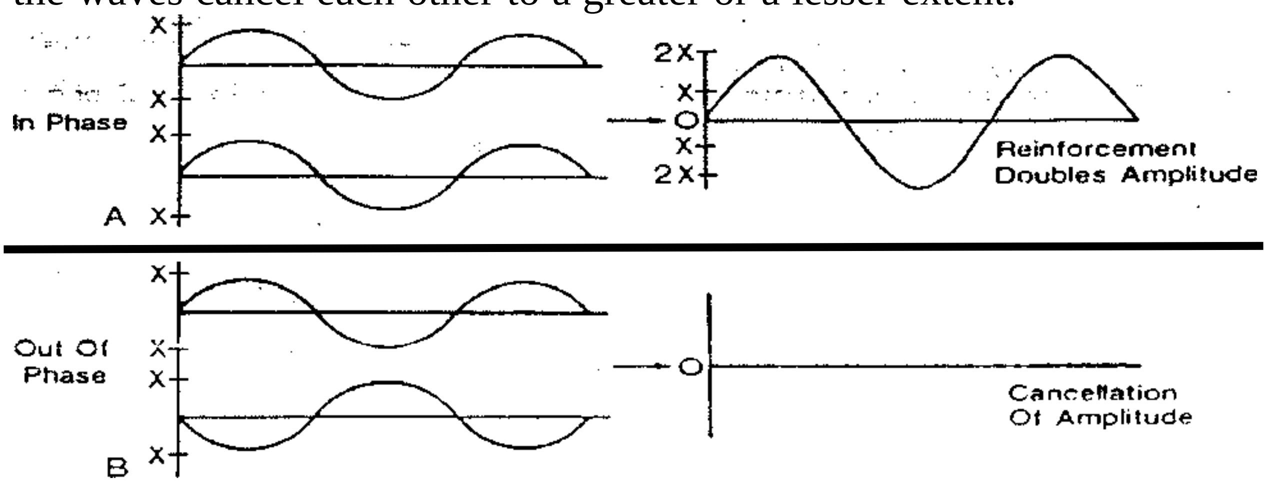
The laser light is perfectly parallel when leaving the laser aperture (figure B), however there is little divergence of laser beam as it exits the laser device, this explains ability of laser beam to trained to long distance with laser light maintains brightness. In practice the beam is often optically focused to a point at convenient working distance from the tissue being irradiated by means of lens.





3. Coherence:

Is a property of laser light that occurs when there is same fixed - phase relationship between two waves of laser light, thus each wave is in phase with the other waves both **longitudinally and transversely.** However, laser light unlike ordinary light source, their waves all in phase and the waves reinforce each other while in an ordinary light, the waves cancel each other to a greater or a lesser extent.



4. Brightness:

Another property of laser light that distinguishes it from ordinary light sources is brightness. This property arises as a result of the parallelism or collimation of the laser light when it moves through space maintaining its concentration and thus, the characteristic high brightness occurs.

Mechanisms of laser-tissue interactions: The light when attacks the tissues interact with tissue, the light energy when attacks the tissues absorbed by tissue ,transmitted and scattered thought tissue and some energy reflected away from the tissue, the results of this interactions is different modes of interaction (different affects).There are many modes of interaction between lasers and tissues:

l. Coagulation: is the mode appropriate for working with soft tissues. If the laser beam incident to tissue with a normal body temperature of 37°C heats the tissues over 60°C. The tissues undergo coagulation phenomenon.

2.Photovaporization: Photovaporization takes place when layers of tissue are heated to high temperatures and liberated as for example when using carbon dioxide laser with intense, highly focused laser radiation produces surface temperatures exceeding 100 °C which cause tissue vaporization.

3. Photoablation : This mode of action occurs when the energy of the laser is used under well controlled to selectively remove thin layers of material causing relatively little thermal damage in the adjacent areas.

4.Photo-disruption: The photo-disruption occurs when the extremely localized high power pulse tends to generate very high instaneous electric field values, which causes electrical breakdown at the tissue interface resulting in ionization, plasma production.

Types of lasers in dentistry:

1-Carbon dioxide laser ($C0_2$1aser): The carbon dioxide lasers have a gas lasing media and fall into far infrared range of the spectrum. This laser has affinity to wet tissues regardless of tissue color. These lasers have wavelengths of 9.3µm and 10.6 µm.

2.Neodymium: yttrium aluminum garnet (Nd:YAG) laser: This laser has lasing media of a crystal of yttrium-aluminum garnet dropped with neodymium, the laser is in the near infrared range of electromagnetic spectrum with wavelength of 1.06 μm. This laser is not well absorbed by water but is absorbed well by pigmented tissue like hemoglobin and melanin. The Nd: YAG laser delivered by optical fibers.

3. Diode laser

The diode laser with wavelengths of 790 nm to 830 nm. It is within the infrared range and can be delivered with thin, flexible light conductor fibers. The diode laser is effective bactericidal in the sterilization of canals of teeth under endodontic treatment.

4. Argon lasers:

Argon laser light has two primary wavelengths; 488 nm and 514 nm, these wavelengths manifest as blue and green visible light respectively, the lasing media is the argon gas.

The argon laser light is absorbed well by oral soft tissue and provides excellent homeostasis, it has affinity for darker colored tissue and also has high affinity for hemoglobin making excellent coagulations. It is not absorbed well by hard tissues and no particular care is needed to protect the teeth during laser surgery. The argon lasers delivered by optical fibers.

The argon lasers with wavelength of 488 nm has ability to cure composite resins. However, the argon laser when used to cure photo activated dental resin materials can reduce curing time, polymerization shrinkage and increase the physical properties and curing depth. While argon laser with wavelength of 514 nm can be used mainly for soft tissue procedures and coagulation.

5. Erbium: yttrium aluminum garnet (Er: YAG) laser:

The wavelength of this type of laser is 2.94 μm, it has ability to ablate or cut dental hard tissue effectively and efficiently. The Er: YAG is well absorbed by water and hydroxylapatite which responsible for it's efficiency in cutting enamel and dentine, with this type of laser the pulpal temperature remained well below the critical temperature (below 5.5 ^{o}C more than body temperature) so the pulpal response to cavity preparation with Er: YAG laser was minimal, comparable or less than the pulpal response created by a high speed turbine hand piece, the cavity prepare by Er: YAG laser has walls are not as smooth as that achieved with high speed hand piece but appear similar to acid-etched surface and if it is used with acid etch procedure produce more bond strength between composite restoration and tooth surface. This laser usually delivered by optical fibers with water spray that serves as cooling system during tooth cutting, also the water increases the efficiency of the cutting.

6. Excimer lasers:

These lasers combine halogen and a noble gas such as argon fluoride, with 193 nm wavelength or xenon chloride with 308 nm wavelength and krypton -fluoride with 248nm as the active medium. Eximer lasers operating in the ultraviolet region. The argon fluoride laser is well suited or show selective removal of necrotic debris from the root canal during endodontic treatment and produce clean very smooth, crack and fissure free dentine walls.

7. Holmium: yttrium aluminum garnet (Ho:YAG) lasers: These lasers used for soft tissues have wavelength of 2120 nm and for hard tissue with wavelength of 2090 nm can be delivered through a fiber optic carrier. These lasers are invisible, it has ability to pass through water, these lasers have affinity to white tissue and cause coagulation can be used for ablation of bone, dentine, cementum, and carious enamel.

8. Erbium chromium : Yttrium scandium gallium garnet (Er.Cr. :YSGG) laser:

This laser has a crystal media with wavelength of 2.78 µm. The laser delivered through a flexible fiber optic cable and focused through a contra-angled hand piece bearing a sapphire tip This laser absorbed by water molecules and also by hydroxyl group in enamel or dentine, thus the Erbium chromium : yttrium scandium gallium garnet. This laser is effective for caries removal and cavity preparation with less discomfort to the patient and better surface treatment enhance bonding of composite resin to the cavity walls.

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Application of dental laser in conservative dentistry :
1- cavity preparation. 2-caries detection. 3-composite curing.
4-dental bleaching. 5-enamel bleaching and dentine conditioning.
6-endodontic instrumentation and sterilization of root canal or canals.

ان الاجابة الوحيدة على الهزيمة هي الانتصار .

Dental laser

Dr. Mohammed Ayad
Lecture (15)

Application of Laser in Conservative Dentistry.

1 - Cavity Preparation

Recently, the use of laser technology has been introduced as an alternative to traditional mechanical rotating instruments for cavity preparation. Bonding of composite resin to Er :YAG and Er.Cr. : YSGG irradiated enamel and dentin surfaces, more than bonding composite resin to diamond-bur prepared surfaces. Dental lasers in cavity preparation free from noise, vibration and no need for local anesthesia would therefore, seem to have an assured future.

Er,Cr:YSGG laser system used in conjugation with air-water spray is effective for preparation of Class I, III and V cavities more conservative cavity preparation because the laser can remove the caries without removal sound enamel below the lesion. The composite resin restorations have more retention and less microleakage

2- Caries detection

The argon laser energy will offer diagnostic capabilities when used to illuminate teeth. When illuminated with argon laser light, carious tissue has a clinical appearance of a dark, fiery, orange-red color and is easily differentiated from sound tooth structure. Decalcified areas appear as a dull, opaque, orange color**.**

A diode laser (**DIAGNOdent,** 655 nm, modulated, 1 mW peak power) depend on laser/light fluorescence appears to show the greatest promise for the detection of dental caries. White-spot lesions without the involvement of bacteria, do not produce a significant increase in fluorescence compared with sound surfaces Distinct increase in fluorescence when the caries process in more advanced stages**.** bacteria or their metabolites could contribute to the fluorescence of carious lesions

3- Polymerization (curing) of composite resin.

The argon laser with 488nm wavelength is used to catalyze dental resin polymerization. This use of the argon laser allows for faster curing of dental resins, and causes the dental resin to have a strong bond to the tooth and less polymerization shrinkage as compared with composite resin cured by the conventional visible light. The optimal curing time for conventional visible light is 44 seconds while for argon laser is 8 seconds.

4- dental bleaching

dental bleaching is whiting of discolored teeth can be done for vital teeth or for root canal treated teeth.

The 35 % of hydrogen peroxide is chemical agent widely used for dental bleaching (tooth whitening) and recently the Argon, diode and CO_2 lasers was used for dental bleaching either alone or in combination with chemical bleaching agent.

The Argon laser is safer and more efficient than diode laser for tooth whitening procedure, and the best results in dental bleaching were achieved with the combination of Argon laser irradiation and the bleaching agents (35% hydrogen peroxide). The Argon laser is used to enhance the activation of bleaching agent.

Some dentist use both Argon and CO_2 lasers in combination with peroxide solution to promote penetration of bleaching agent into the tooth to provide bleaching below tooth surface giving better and faster bleaching

5- Enamel etching and Dentin conditioning.

The Er :YAG and Er.Cr. : YSGG and CO_2 lasers energy is absorbed strongly by enamel and dentine and can produce both chemical and physical changes on the enamel surface which can be of therapeutic value. Roughening of the enamel surface through the creation of bubble-like inclusions because laser treatment induces melting and recrystalization of hydroxylapatite resulting the formation of bubbles-like inclusions.

Etching enamel and dentine using pulsed carbon dioxide (CO_2) laser radiation has been shown to give acceptable bond strengths when hydrophobic enamel bonding resins are used between the lased surface and composite resin**.**

The effects of laser on dentine have many beneficial like desensitization of hypersensitive exposed dentine by melting and recrystalization of dentine causing closure of open dental tubules.

6-Uses of Laser in endodontic treatment:

A - Root canal preparation by laser

The hand instrumentation left some of the walls untouched and left smear layer containing bacteria covering the instrumented walls. The laser preparation on the other hand gives clean and smear layer free root canal walls with dentine has crusty, wavy aspect with open dentinal tubules.

Usually combination of hand instrumentation and laser preparation gives better results, in this technique the apical region of the canal is hand instrumented to the size 15 K file then the laser energy will applied to the canal by optic fiber(200μm in diameter which equal to size 20 K-file) inserted to the working length and enlargement was performed circumferentially starting in apical third, then the middle third and finally the cervical third.

B-Sealing of the apex and dentinal tubules and repair crack in the tooth by laser:

The laser with optic fiber made from hydroxyapatite can seal the root apex and plug open dentinal tubules and repair a cracks in the tooth by melting and deposition of the hydroxyapatite fiber optic during laser application inside the root canal.

C- PIPS (Photon induced photoacoustic streaming)

Irrigation of root canal system before three dimensional obturaion is very important step in elimination of smear layer and remnant debris in an inaccessible areas of root canal system. PIPS is a technique recently develop to assist in this process. Recent studies have reported how the use of an Er:YAG laser, equipped with the newly designed radial and stripped tip, in combination with 17% EDTA solution, using a very low pulse duration (50 microseconds) and low energy (20 mJ) resulted in effective debris and smear layer removal with minimal or no thermal damage to the organic dentinal structure through a photoacoustic technique called Photon Induced Photoacoustic Streaming or “PIPS™”. Also, the same PIPS™ protocol in combination with 6% sodium hypochlorite solution has been investigated and shown to reduce the bacterial load and its associated biofilm in the root canal system three dimensionally.

D-Obturation of root canal by laser:

The laser (Argon or CO_2 or Nd:YAG laser) used to obturat the root canal through softening the gutta percha filling material by heat generated from laser application.

Power density and energy density:

The power density: is simply the number of photons per unit area, power density is the most important factor in detection the effectiveness of any laser device. When using continuous laser systems power/ area functions are extremely important. To enhance the effectiveness of laser beam and to provide an increase in power, a focusing lens can reduce the diameter of the sport to produce greater power densities at focal spot area thus enhancing tissue effects of the laser, the power density will determine the ability of the laser to vaporize, excise and coagulate biologic tissue.

To calculate power density expressed in watt per square centimeter it can be shown that the power density is directly proportional to the wattage employed and inversely proportional to the area of the spot therefore:

Power density (watt/cm^2) = power(watt) / area(cm^2)

Energy density (**energy flounce):** It is the energy perceived per unit area. It can be calculated from the product of power density and exposure time. Energy density is measured by (Joule/cm^2). It determines the extent of tissue vaporization or coagulation or ablation. When using pulsed laser systems power/ time functions are extremely important. The energy density is directly proportional to the power and exposure time and inversely proportional to the exposed surface area of the target tissue.

Energy density (Joule/cm^2)=(power (watt) x exposure time (second))/area (cm^2)

Laser hazard (adverse effects):

The lasers have many adverse effects when used with inappropriate handling, these effects may affect on patient or dental staff.

A-Retinal adverse effects:

The effect of laser radiation upon retinal tissue may be a temporary change without pathological reactions, or it may be more sever, varying from small indistinguishable lesions to gross damage of the retina. The mildest observable effect may be simple reddening. With increasing energy, lesion may occur, progressing from edema to charring with hemorrhaging and secondary effects about the lesion. With very high energy, gases from which can disrupt the retina and may create small explosions in the eye.

B-Corneal and skin effects

Ultraviolet radiation (200-400nm) is absorbed at the cornea and can cause painful damage. It can cause conjunctivitis and erythema to the face and other exposed tissue. The severity depending on the wavelength of the ultraviolet radiation. The general effect of ultraviolet radiation is that of sever sun burn.

Infrared radiation is also absorbed by the cornea and by the skin and is converted to heat, with the overall effect being a heating of the tissue on a localized basis. Many tissues are quite sensitive to thermal changes and can be damaged when even slight temperature change occur. Infrared radiation has been shown to cause eye lens opacities.

C-Air borne contaminations :

The laser smocks (plume) or vapor emitted from the site of application during exposures to laser energy, is regarded as potentially hazardous both in term of particulate and infectivity. The CO_2 smocks have harmful effect on the respiratory system, thus evacuation and ventilation to the outside and adequate suction in the lasing site must be maintained at all time.

Laser safety:

Precaution for dental staff and patients are essential during laser procedures to protect non-target tissue particularly the eyes from stray beams. Reflective surfaces such as instruments, mirrors and even polished restorations have potential to redirect laser energy. Matte instruments are advisable, also protective eyeglasses for patient and staff. Usually green safety glasses are required for use with Nd : YAG lasers and amber colored glasses for use with Argon laser, while for CO_2 laser clear glasses are indicated. In addition, the patient eyes should be covered with moist gauze pads.

The non-target oral tissues should be shielded with wet gauze packs. The laser plume created when tissue vaporizes should be considered infectious thus an appropriate evacuation system to draw off and filter the plume is essential. As with any procedure involving potential contamination by blood or other body fluids, the operator and assistant should wear glasses and surgical masks. Extreme caution must be used when operating a laser in the area with explosive gasses such as anesthetics.

Dr. Mohammed Ayad

Lecture (16) **Operative Dentistry**

Cervical Lesions (Carious and non-carious)

Cervical lesions (or class V lesions) include those carious and non-carious defects found in the gingival third of facial and lingual tooth surfaces. Class V carious lesions are produced by bacterial plaque attaching to the surface of teeth and producing acids that cause demineralization. A class V lesion resulting from factors other than dental caries is known as a non-carious cervical lesion (NCCL).

Caries lesion

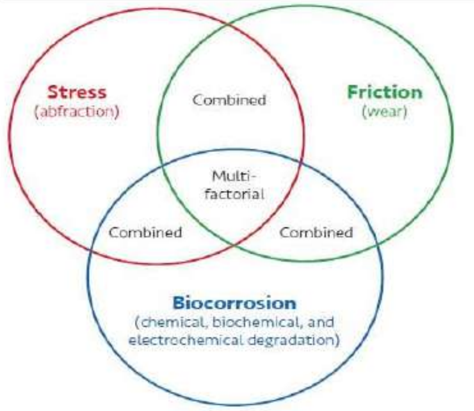
Cervical lesions involving enamel structure (coronal to CEJ) can be easily detected visually (change in color). However, tooth color is not a good predictor of root caries damage. A root surface may be discolored and still have a hard sclerotic surface that would not warrant preparation and placement of a restoration unless the discoloration presented an acidic problem for the patient. In contrast, some root caries lesions will have the color of healthy tooth structure, but will be soft when tested with a dental instrument. Caries disclosing dyes may be inconsistent in identifying demineralized cementum/dentin on root surfaces. The best correlation to date for clinical detection of caries lesion on root surfaces is the softness of the surface has evaluated with a dental instrument.

Non Carious Cervical Lesions

It is now generally accepted that NCCLs have a multifactorial etiology comprising stress, friction, and biocorrosion.

The prevalence of NCCLs, regardless of form or etiology, varies from 5% to 85% in modern dentitions.

These lesions are most commonly found in premolars and molars, and the prevalence and severity have been shown to increase with age.



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Erosion: loss of tooth structure due to chemical action. This can be prominent in patients with oral habits such as constant citrus ingestion, or chlorinated swimming pool water, or gastrointestinal problems that produce repeated exposure of teeth to gastric acids. In these cases, the oral lesions generally present a rounded-cupped out defects.

In early stages, the acidic action produces a smooth and silk glazed enamel surface. In these situations, the lesions are located coronal to the CEJ and present an intact ring of enamel along the gingival margin.

In intermediate stage, shallow flat concavities with rounded borders developed. In some situations, the enamel is totally removed, leading to exposure of dentin and a polished-looking surface. Clinically, rounding of the cusps, grooves, and incisal edges can occur.

In more severe cases, when the continuing biocorrosive loss of dentin occurs, reactionary and reparative dentin forms, thus obliterating the dentinal tubules as a biologic response to compensate for the loss of tooth substance.

Box 5-2	Habits that accelerate dental chemical degradation and should be avoided[74]

- Frequent consumption of acidic drinks
- Swishing the drink before swallowing
- Consuming acidic drinks just before sleep, when the protective benefits of saliva are reduced
- Brushing teeth immediately following the acid challenge, which increases the wear of the enamel due to the abrasive action of the toothpaste on the still-softened tooth surface

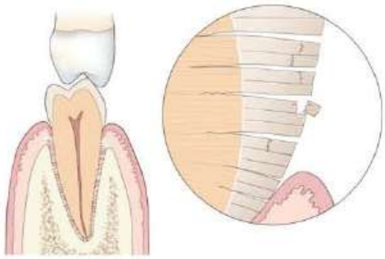
Abrasion: loss of tooth structure by mechanical or frictional forces. These lesions are commonly caused by excessive tooth brushing; also, these defects may be produced by repeated and excessive forces by other materials and appliances such as dental floss, tooth picks or removable appliances.

The lesions commonly caused by brushing appear as V-shaped notches in teeth.

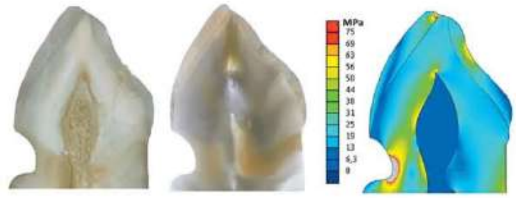
The main factors affecting the abrasion from tooth brushing are:

1. The particular brushing technique
2. Type of tooth brush
3. Abrasiveness of tooth paste
4. The duration and intensity of brushing

Abfraction: loss of tooth structure due to flexural forces. It is a theory proposed to explain the development of some V-shaped notches in teeth. The theory states that as teeth flex under occlusal load, stresses are transmitted to the cervical area causing cervical enamel rods to fracture and dislodge.



This occurs in patients with heavy occlusal loads and clinical evidence of bruxism.



Access and Isolation

When cervical lesions occur supragingivally, access to the area is easy, but if the lesion progressed below the free gingival margin, isolation for complete caries removal, tooth preparation, restoration placement and finishing is difficult.

If a restoration is placed without obtaining complete access to sound tooth structure on all margins, carious tooth structure may remain and the restoration may fail. Even in non-carious lesion, inability to gain sufficient access to the gingival margin may result in poor restoration-tooth interface, increased microleakage and premature loss of the restoration.

Class V lesions can be adequately treated using cotton rolls, retraction cord. If the lesion extends below gingival margin a rubber dam is useful. When a rubber dam fails to provide complete visualization and access to the entire lesion, a surgical approach must be used (gingivoplasty). It is advantageous to have periodontal surgical procedures accomplished before tooth restoration (at least 6 weeks) to allow gingival margin to heal to its stable position.

Treatment:

If active caries is present, treatment must be initiated to control the active disease and to prevent disease progression.

Non-carious cervical lesions should be treated

- to protect remaining tooth structure if the amount of tooth lost is extensive or progressing.
- if esthetic is compromised.
- to control or reduce sensitivity.
- to accommodate removable partial denture clasp design.

Non- carious lesions that are not extensive and are asymptomatic, these are preferable treated by prophylaxis which include:

Tooth Wear: Prophylaxis/therapy

– Good diagnosis → Causal therapy
– Prophylactic changes in possible causal factors
– Fluoride
– Documentation and follow-up

Once the decision to place a restoration is made, the dentist must select a restorative material and design the cavity preparation. For any class V restoration, the extent of restoration should be determined by the extent of the lesion. All demineralized tooth structure and unsupported enamel should be removed.

Restorative materials used in class V restoration:

1. **<u>Non esthetic materials</u>:**
   - Amalgam.
   - Gold foil (direct) not widely used.

- Gold inlay not widely used.

2. **Esthetic materials:**

- Resin composite (with dentin bonding system).
- Resin composite with glass-ionomer base (sandwich technique). Glass-ionomer is used to replace the missing dentin, reduce microleakage and increase retention, while a veneer of composite resin is placed to enhance esthetics and polishability and increase abrasion resistance of the restoration.
- Flowable resin composite.
- Glass ionomer.
- Resin-modified glass ionomer.
- Compomer.
- Porcelain inlay (not widely used).

Sandwich technique (laminated technique): this technique is useful combining the advantages of both glass ionomer cement (GIC) and composite resin. It can be open or closed. Open technique in which the GIC at the gingival margin is exposed. Closed technique in which the GIC is completely covered by resin composite. This technique uses GIC as intermediate layer between dentin and resin composite.

Dentinal Sensitivity

Dentinal sensitivity, it is a problem often associated with gingival recession and non-carious cervical lesions. Sensitivity is caused by exposure of dentinal tubules that communicate between the pulp and the oral cavity. The degree of sensitivity is influenced by the number and size of the open tubules. Changes in the direction of fluid movement within open tubules are perceived as pain by mechanoreceptors near the pulp. Tactile, thermal or osmotic stimuli can induce changes in fluid flow and elicit a pain response.

Treatment

Dentinal hypersensitivity secondary to gingival recession is best treated surgically with root coverage procedures such as connective tissue grafts.

Treatment or prevention of hypersensitivity is accomplished by the use of some method to occlude the open tubules by:

- Dentin adhesives provide short-term relief.
- Oxalate solutions used alone or in combination with electrophoresis is successful.
- Stannous fluorides have also been used with positive results.
- Potassium nitrate available in dentifrices or as a gel for application in the dental office is also reported to be an effective desensitizing agent. It is thought to act directly on nerve membranes to reduce sensory nerve activity rather than causing occlusion of the tubules.

Dr. Mohammed Ayad

Lecture (17) ***Operative Dentistry***

Indirect aesthetic adhesive restorations Inlays (and Onlays (materials ,techniques CAD/CAM Technology

Aesthetic appearance is very crucial in modern dentistry. Patients are attracted to a restoration that matches the color of their natural teeth. Hence, an esthetic restorative material must simulate the natural tooth in color, translucence, and texture, yet must have adequate strength and wear characteristics, good marginal adaptation and sealing, insolubility, and biocompatibility. These materials must also remain color stable and maintain external tooth morphology to provide a lasting esthetic restoration.

Options for tooth-colored restorations include ceramics and direct and indirect composite based materials. The success of the treatment depends on the correct selection of the restorative material and restorative technique.

The directly placed composite resin restoration is clearly the most conservative posterior restoration in contemporary dentistry. Although this technique requires only that diseased tooth structures be removed and replaced, direct resin is subject to shrinkage when it is light cured. This can result in stretch forces on the bond or the tooth with the potential for postoperative sensitivity and/or microleakage if these forces are not relieved by elastomeric flow in the resin. Although this development is less problematic in smaller class II cavities and can be controlled or limited somewhat by technique, it is of greater concern in larger carious lesions. Esthetic inlay and onlay restorations attempt to minimize this inherent property of light-cured resins, because only the thin layer of luting resin is subject to polymerization shrinkage at restoration placement.

Indirect esthetic restorations are those fabricated outside the oral cavity. Tooth colored indirect systems include laboratory processed composites or ceramics such as porcelain fired on refractory dies or hot pressed glasses. In addition, computer aided design/ computer assisted manufacturing (CAD/CAM) system is currently available and is used to fabricate ceramic restorations.

The advantages of indirect esthetic restorations over direct composite are improved physical properties, better wear resistance, reduced polymerization shrinkage, ability to strengthen remaining tooth structure, more precise control of contours and contacts, biocompatible and good tissue response.

In comparison to ceramic materials, inlay or onlay restorations composed of composite resin can generally be fabricated with greater ease in the laboratory. Resins also demonstrate improved wear compatibility against opposing tooth structure and can be repaired more easily intra-orally. For inlays, indirect composite seems to be currently the preferred material. For onlays the marketplace is weighted more toward ceramics than indirect composite but not by much. Numerous clinical trials have shown ceramic inlays or onlays to be viable restorations over time.

Indirect composite restorations can be fabricated entirely in the lab (indirect technique) or using combined direct/indirect techniques. The direct/indirect technique can be performed entirely inside the dental office (semi-direct intraoral technique) where composite resin is placed directly into the cavity, condensed, carved and cured, then removed for extraoral final curing before being cemented. This technique requires no impression nor temporization. The second type of direct/indirect technique necessitate an impression is made and the restoration is fabricated on the resultant model (semi-direct extraoral technique).

Effectiveness and Potential Longevity

For esthetic inlays or onlays, evidence supports the effectiveness of enamel bonds with regard to tooth reinforcement. The literature lists tooth reinforcement numbers that indicate that when there are significant enamel bond surfaces, tooth reinforcement is achieved, even up to 70% to 80% of the original strength of the tooth. Clinical evidence also supports the longevity of these restorations. A significant number of patients show longevity greater than 10 years.

Maintenance

There are two aspects to maintenance: normal patient maintenance (brushing, flossing, and routine home care) and reparability of the restoration. Compared with ceramic, indirect composite is more predictable in terms of intra-oral repair. Having a reparable restoration extends its longevity without replacement issues, which almost always involve the removal of extra tooth structure and added tooth trauma.

In repair of an indirect composite resin, first the fractured area (including the enamel and the existing resin composite restoration) is roughened using a diamond bur. Often the restoration is also micro-etched before etching of the cavity and placement of the bonding agent. The missing structure is then built up in direct composite. The restoration is then finished and polished.

Dr. Mohammed Ayad

Lecture (18)

Operative Dentistry

Indirect Tooth Colored Restorations

Indirect esthetic restorations of posterior teeth (Inlays and onlys) are used for restoring relatively extensively decayed or damaged tooth structures without the need to replace the whole outer enamel of the tooth as with crowns. Since less tooth structure is removed so inlays and onlays tend to be more conservative and esthetic than crowns. In spite of the fact that simplicity of restorative dentistry dictates direct approach including cavity preparation and immediate restoration of any tooth defect; yet, in some cases indirect restoration may be the only successful sort of restoration.

Inlay and onlay

An inlay is an indirect restoration (fabricated outside the oral cavity) constructed of cast metal, porcelain ceramic, or composite resin that neither supports nor replaces a cusp or cusps of a tooth. The inlay restoration is nothing more than a centric stop in that it provides no protection for the cusp tip during lateral and/or protrusive masticatory excursionary forces.

An onlay is an indirect restoration that covers one or more cusps, extending through and beyond the cusp tip to the facial/lingual and proximal slopes of the covered cusps. It may be fabricated from any of the materials used for inlay restorations. It is implicit in this type of restoration that occlusion in all functional positions is supported by restorative material rather than the tooth structure of the covered cusps.

Indications

1. Esthetics: Indirect tooth-colored restorations are indicated for Class I and II restorations located in areas of esthetic importance for the patient.
2. Large defects or previous restorations: Indirect tooth colored restorations should be considered for restoration of large Class I and II defects or replacement of large compromised existing restorations, especially those that are wide faciolingually and require cusp coverage. Large preparations are best restored with adhesive restorations that strengthen the remaining tooth structure. The contours of large restorations are more easily developed when using indirect techniques, and materials of indirect restoration are more

durable. The wear resistance provided by indirect materials is especially important in large posterior restorations that involve most or all of the occlusal contacts. However, without sufficient bulk, an extensive indirect ceramic or composite restoration might fracture under occlusal loading, particularly in the molar region.

3. Uncooperative patient: wise management of such patients requires minimizing chair side time by taking an accurate impression and completing most of the restorative steps outside the patient's mouth.
4. Solving of occlusal problems such as attrition with decreased vertical dimension and collapsed lower third of the face which may cause temporomandibular joint troubles.
5. Correction of esthetic defect, such as excessive discoloration caused by fluorosis, and tetracycline stains when it is difficult to be removed by other esthetic alternatives.
6. Lack of accessibility.

In addition to general indications for indirect restorations the following conditions should be present:

1. Good standard of oral hygiene.
2. Cavities free from marked undercuts.
3. Sufficient tooth structure available for bonding.
4. Occlusal load must not exceed the flexural strength of the restoration/tooth complex.
5. The tooth must not show evidence of excessive wear.
6. Ideally, the cavity margins must be placed in enamel.

Contraindications

1. Heavy occlusal forces: Ceramic restorations can fracture when they lack sufficient bulk or are subject to excessive occlusal stress, as in patients who have bruxing or clenching habits.
2. Inability to maintain a dry field: Despite some research suggesting that modern dental adhesives can counteract certain types of contamination, adhesive techniques require near-perfect moisture control to ensure successful long-term clinical results.
3. Deep subgingival preparations: Although this is not an absolute contraindication, preparations with deep subgingival margins should be avoided because these margins are difficult to record with an impression and

are difficult to finish. Additionally, bonding to enamel margins is greatly preferred, especially along gingival margins of proximal boxes.

4. Poor oral hygiene.
5. Insufficient tooth structure available for bonding.

Composite Inlays and Onlays

While the newest direct composite resins offer excellent optical and mechanical properties, their use in larger posterior restorations is still a challenge since polymerization shrinkage remains a concern. This shrinkage can lead to improper sealing, which results in microleakage, postoperative sensitivity, and recurrent caries. The achievement of a proper interproximal contact and the complete cure of composite resins in the deepest regions of a cavity are other challenges. However, no method has completely eliminated the problem of marginal microleakage associated with direct composite.

Indirect resin composites (IRCs) were introduced to overcome the problems associated with polymerization shrinkage and secondly to improve the properties of the material because polymerization shrinkage occurs on the bench and not in the mouth. These goals are achieved through the post-polymerization phase (which is a final phase of curing after the initial light curing phase) that can be light, thermal, or a combination of both, with or without nitrogen pressure. This phase has a dual purpose, on one hand, it allows to obtain a high conversion rate (percentage of polymerized composite); on the other hand, it improves the mechanical and optical properties of the material. This technique would allow to reach a degree of conversion close to 100%, which would reduce the internal stress generated by the polymerization shrinkage by appreciably improving the fitness of the restorations.

With good operator and laboratory skills, they can be superior in physical properties, interproximal contours, occlusion, and aesthetics compared with a majority of large direct composites observed clinically.

Types of indirect composite

First generation IRCs

The first generation IRCs had a composition identical to that of the direct resin composite marketed by the same manufacturer and the materials also bore names similar to those of the direct materials.

Upon light initiation, camphoroquinone decomposes to form free radicals and initiates polymerization, resulting in the formation of a highly crosslinked polymer. It is observed that 25%–50% of the methacrylate group remains unpolymerized. For inlay composites, an additional or secondary cure is given extraorally, which improves the degree of conversion and also reduces the side effects of polymerization shrinkage. The only shrinkage that is unavoidable is that of the luting cement.

It was observed that the first-generation IRCs showed improved properties only in lab studies but had failures in clinical studies. They suffered from low flexural strength, low modulus of elasticity and low resistance to wear abrasion. These poor physical properties were the result of low filler load and high matrix load. Examples of this generation includes Visio-Gem (ESPE), Dentacolor (Kulzer), SR Isosit inlay system, Coltene Brilliant, and Concept (Ivoclar).

Second generation IRCs

The clinical failures endured with first generation composites and the limitations faced with ceramic restorations led to the development of improved second generation composites. The improvements occurred mainly in three areas: structure and composition, polymerization technique, and fiber reinforcement. The second generation composites have 'microhybrid' filler with a diameter of 0.041μ, which is in contrast to that of the first generation composites that were microfilled. The filler content was also twice that of the organic matrix in the latter composites. By increasing the filler load, the mechanical properties and wear resistance is improved, and by reducing the organic resin matrix, the polymerization shrinkage is reduced. Examples include Artglass and belleGlass HP, and Solidex (Shofu).

Ceramic Inlays and Onlays

Ceramic inlays and onlays have become popular not only because of patient demand for esthetic, durable restorative materials, but also because of improvements in materials, fabrication techniques, adhesives, and resin-based luting agents. Among the ceramic materials used are feldspathic porcelain, hot pressed ceramics, and machinable ceramics designed for use with CAD/CAM systems. The physical and mechanical properties of ceramics come closer to matching those of enamel than do composites. They have excellent wear resistance and a coefficient of thermal expansion close to that of tooth structure.

Feldspathic Porcelain Inlays and Onlays

Dental porcelains are partially crystalline minerals (feldspar, silica, alumina) dispersed in a glass matrix. Porcelain restorations are made from finely ground ceramic powders that are mixed with distilled water or a special liquid, shaped into the desired form, then fired and fused together to form a translucent material that looks like tooth structure. Currently, some ceramic inlays and onlays are fabricated in the dental laboratory by firing dental porcelains on refractory dies.

Hot Pressed Glass-Ceramics

In 1968, it was discovered that certain glasses could be modified with nucleating agents and, on heat treatment, be changed into ceramics with organized crystalline forms. Such "glass-ceramics" were stronger, had a higher melting point than non-crystalline glass, and had variable coefficients of thermal expansion.

A glass-ceramic material such as Dicor (Dentsply International) was rapidly became a popular dental restorations. A major disadvantage of Dicor was its translucency, which necessitated external application of all shading. Dicor restorations were made using a lost-wax, centrifugal casting process. Newer leucite-reinforced glass-ceramic systems also use the lost-wax method, but the material is heated to a high temperature and pneumatically pressed, rather than centrifuged, into a mold.

Indirect Composite Inlay Vs Ceramic Inlay

The aesthetic integration is the same for the both materials, composite and ceramic. Indeed, the wide range of shades currently available can mimic the tooth in its finest details. Thanks to the bonding, composite or ceramic inlay helps strengthen the structure of the decayed tooth, creating a homogeneous structure. The bonding also allows a good marginal adaptation, when the different steps are respected. The stability of ceramics in time is well established, the composite stability depends on the respect of the cooking and polymerization steps, and especially a good final polishing. As for the hardness, the ceramic inlay largely exceeds the composite inlay. It could even cause long-term abrasion of the opposing teeth, reason why the use of the ceramic inlay is not indi- cated in the presence of parafunctions. The higher cost as well as the difficulty of manufacturing of the ceramic inlay; would tip the balance of the advantages of the composite inlay. Indirect composite inlay remains an excellent alternative, less expensive especially in cases of bruxism.

Dr. Mohammed Ayad

Lecture (19) **Operative Dentistry**

Techniques of posterior composite Inlay/Onlay restoration system
Laboratory-processed composite inlays and onlays

Techniques for fabrication of composite resin inlays

There are two main different techniques for fabrication of composite resin inlays and onlays:

I. Combined direct/indirect (semidirect) technique, (in-office).
A-Semi-direct intraoral technique.
B-Semi-direct extraoral technique (flexible model technique)
II. The indirect technique on stone die (in-office or in laboratory).

I) Direct / indirect (Semi-direct) technique

I. A- Semi-direct intraoral technique

Steps for fabrication

1- Lubrication of the inlay preparation

The tooth and cavity preparation are painted with a lubricant on a disposable brush. This lubricant must be compatible with the composite resin inlay restorative material and will allow inlay removal after intraoral light curing.

2- Matrix and wedge placement

1. A retainerless contoured, clear matrix is placed and clear reflecting wedges are placed at the interproximal gingival margins.
2. The wedges are firmly placed to create rapid separation of the teeth, compensating for thickness of the Mylar matrix band and allowing for establishing the interproximal contact between the inlay and adjacent teeth.

3- Composite resin inlay material placement

A high-viscosity resin paste, is placed into the proximal box, and gently condensed with a ball burnisher. The occlusal portion of the preparation is completely filled and gently condensed with a ball burnisher. The burnisher is preferable to be lightly coated with a primer or resin adhesive to prevent the composite resin from sticking to the end of the burnisher. The interproximal area is cured for 60 seconds, followed by curing the occlusal surface for 60 seconds also.

4- Inlay removal

After the completion of light curing, the inlay must be removed from the preparation gently.

5- Oven tempering

Separator lubricant is painted on all the inlay surfaces. This will allow the inlay to completely cure without an oxygen inhibited layer. The oxygen inhibited layer is a sticky, resin-rich uncured layer and always present when a composite or bonding resin is polymerized in air and should be prevented whenever possible.

The inlay is then light cured for an additional 60 seconds. The composite resin inlay must be tempered in a special tempering oven.

I. B- Semi-direct extraoral technique (The flexible model technique)

It is an alternative to using the natural tooth as the die for inlay fabrication. It is a completely extraoral technique that can be performed in one appointment and that does not require a provisional restoration.

Steps for fabrication

A polyvinyl siloxane impression or an irreversible hydrocolloid impression is made that capture all the margins of the preparation (single quadrant impression). When a polyvinyl silicone impression is made, a silicone releasing agent should be sprayed onto it (acting as a separating medium). The flexible-working model is fabricated by injecting a firm-setting polyvinyl siloxane impression material (light bodied material) into the preparation impression, followed with a putty material to form a flexible cast. After setting, the impressions are separated. The resin inlay is now fabricated as with the semi-direct intraoral technique.

Advantages of flexible model technique

1. There is lower cost, more convenience and less trauma for the patient than indirect technique.
2. The dentist, an in-office laboratory technician, or a trained assistant can make the restoration.
3. Provisional restoration is not needed, reducing time and cost and eliminating contamination of tooth preparation by provisional cement debris.
4. Less polymerization shrinkage occurs.
5. The technique requires minimal clinical time (it is possible to seat the restoration 8 minutes after impression).

Disadvantages of this technique

1-The cost of impression materials and the time needed for impression material to set and possible deformation of the original impression when making the flexible die.

2-Tooth preparation should not have thin, weak cusps because the accuracy of the die is compromised as a result of the flexibility of the silicone die.

3-The opposing reference is not available because the restoration is generated on a single base from a single quadrant impression.

II) Indirect Technique

In this technique, impressions are needed for inlay fabrication.

The indirect inlay technique can be performed as either a one-visit (in-office) or two-visit method (laboratory fabrication).

Steps for fabrication

1. Impression making

The impression should be made with either a polyether or a vinyl polysiloxane impression materials.

a. It should be poured in a die stone immediately and sent to a dental laboratory.
b. For the in-office technique, a fast-setting stone (set within 5 minutes) should be used.

2. Provisionalization (will be discussed later)

3. Cast Preparation

Once the die stone is set, the cast should be mounted and sectioned in preparation for the inlay fabrication. Care should be taken when the cast is sectioned, so that the gingival contacts should remain intact.

4. Inlay Fabrication

The preparation margins are outlined with a red pencil, and a separating medium is applied to the internal surface of the die as well as to the surrounding and opposing teeth, then dried with a gentle air stream. Build the composite resin of the correct shade. The composite resin can be built up in two layers if shading of dentin and enamel is desired. Light curing for 40 seconds. The inlay is then removed from the die by pressing on the proximal surface in an occlusal direction.

5. Heat Treatment

The resin inlay is heat treated in an oven for 18 minutes at 100°C in a heat-curing oven (according to manufacturer's instructions).

6. Finishing and polishing

After heat treatment, the inlay is carved on the die with fine diamonds and mounted abrasive stones. The inlay is then polished with composite polishing paste on a buff wheel.

7. Characterization

The inlay is thoroughly cleaned ultrasonically in a water bath. It can be characterized by resin-based colorants to the surface of the inlay. This characterizing stain is applied to pits and fissures with a brush. The stain is then light cured for 40 seconds.

Inlay and onlay provisional restoration

A provisional restoration is necessary when using indirect systems that require more than one appointment. The temporary restoration protects the pulp-dentin complex in vital teeth, maintains the position of the prepared tooth in the arch, and protects the soft tissues adjacent to prepared areas. The temporary restoration can be made using conventional techniques from acrylic resins or bis-acryl composite materials.

Care should be taken to avoid the bonding of the temporary material to the preparation at this phase of the procedure. A lubricant of some sort can be applied to the preparation if desired, especially if a resin-based material was used to block out undercuts and level the walls of the preparation.

Temporary restorations for porcelain fused to metal and cast gold restorations typically are cemented with eugenol based temporary cements. Eugenol is believed to interfere with resin polymerization. However, ceramic and composite indirect restorations rely on adhesive cementation and hence the use of eugenol could potentially reduce the adhesion of the permanent resin cement to tooth structure; although, some studies reported that this issue can be overcomed if the preparation is pumiced before cementation of the permanent restoration. In general, it is recommended to avoid eugenol cement and to use a non-eugenol temporary one for temporary cementation. For exceptionally non-retentive preparations, or when the temporary phase is expected to last longer than 2 to 3 weeks, zinc phosphate or polycarboxylate cements can be used to increase retention of the temporary restoration.

The aims of provisionalization (temporarization) are:

a. Protecting the pulp-dentin complex from any bacterial, mechanical, and thermal aggression and covering exposed dentin to prevent tooth sensitivity, plaque buildup, cavities, and pulp problems.
b. Stabilizing relations with proximal and antagonist teeth (preventing unwanted tooth movement).
c. Maintaining an acceptable function and enabling patients to eat and speak normally.
d. Serving as a diagnostic tool. Maintaining the health and contours of the periodontal tissue.

Technique of Provisionalization

Self-cured acrylic resin or Bis-Acryl composite material can be used for fabrication of temporary restoration. The restoration can be constructed directly on the prepared tooth in the patient's mouth.

a. The patient's saliva may be pained into the preparation to act as a lubricant.
b. Two drops of monomer liquid are placed into a dappen dish and the powder is added to form a runny mix of acrylic resin. When the mix becomes doughy, it is placed into the cavity with an angled flat plastic instrument.
c. The patient should close into maximum intercuspation and go through all mandibular excursive movements to adjust the occlusion. If flexible type of composite resin is used it should be light cured for 40 seconds.
d. After polymerization, the acrylic resin restoration is removed from the tooth. Any excess acrylic resin is trimmed with acrylic resin burs or abrasive disks and the margins are finished.
e. The restoration is placed back into the tooth preparation to evaluate the fit and marginal adaptation. Articulating paper is used to check the occlusion and make any adjustments. Then glazed with a light cured glazing resin.
f. The restoration is cemented with non-eugenol based temporary cement.

Dr. Mohammed Ayad

Lecture (20) **Operative Dentistry**

Ceramic veneers, inlays and onlays, clinical procedures

Ceramic veneers

A veneer is a layer of tooth-colored material that is applied to a tooth to restore localized or generalized defects and treat intrinsic discolorations. The veneer has gained wide acceptance in recent years as a primary restoration in esthetic dentistry. Since its introduction in the early 1980s, it has undergone an evolution in both techniques and materials.

Ceramic veneers are used to modify the tooth color, shape, length, and/or alignment; to close space; and to restore fractured teeth. Advantages of indirect veneers include conservative tooth preparation (about 0.5 mm facial reduction), no anaesthesia is needed since preparation is confined to enamel layer, good abrasion resistance and excellent esthetics and color matching.

Full veneers can be accomplished by the direct or indirect technique. When only a few teeth are involved or when the entire facial surface is not faulty (i.e., partial veneers), directly applied composite veneers can be completed chairside in one appointment for the patient. Placing direct composite full veneers is time consuming. For cases involving young children or a single discolored tooth, or when the patient's time or money is limited, precluding a laboratory-fabricated veneer, the direct technique is a viable option. Indirect veneers require two appointments but typically offer three advantages over directly placed full veneers:

1. Indirectly fabricated veneers are much less sensitive to operator technique. Considerable artistic expertise and attention to detail are required to consistently achieve esthetically pleasing and physiologically sound direct veneers. Indirect veneers are made by a laboratory technician and are typically more esthetic.
2. If multiple teeth are to be veneered, indirect veneers usually can be placed much more expeditiously.
3. Indirect veneers typically last much longer than do direct veneers, especially if they are made of porcelain or pressed ceramic.

Clinical steps

At the pre-operative appointment, a full set of digital photographic images is recorded, including full-face, smile, retracted, and occlusal views. Photography serves as a communication tool between doctor and patient and doctor and laboratory, provides documentation, and is a learning tool.

Smile design principles are followed in a critique of the angulation, proportions, and alignment of each tooth for the patient and the technician provides a complete wax-up of the case upon which the dentist can rely on to produce the mock-up provisional for the patient. The patient can actually preview the final result through the provisional process. The patient normally wears the provisionals for 2 to 3 weeks.

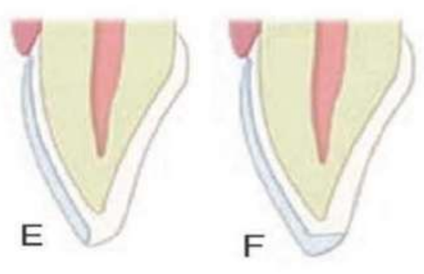
Tooth preparation

The main objective of tooth preparation is to create sufficient space for the restorative material to exhibit excellent esthetics and fracture resistance when in function. For ceramic veneers, the minimum required thickness is approximately 0.3 to 0.5 mm on the facial surface, and 1.5 mm on the incisal edge.

In the classic preparation technique, such reduction is performed directly on dental element, but since most cases teeth require veneering for modifying their final shape and contour (as the case with teeth with abrasion, erosion or attrition, or diastemas closing). For example, one intends to increase the incisal edge by 1.5 mm, the space required for the restorative material already exists, and it is therefore unnecessary to reduce the natural tooth in that region. Therefore, "the mock-up driven technique" is carried out in which preparation is performed directly on the mock-up as if it was a natural tooth. This technique results in considerably less invasive dental preparations, since it takes into account the final contour desired for the veneer. Another preparation technique could be used which is the "the silicone index technique" using a silicone impression as a guide for preparation.

In general, there are three types of veneer preparation designs:

1. Window preparation: recommended mostly for direct veneer.
2. Butt-joint incisal preparation: It is the simplest design and is used to provide adequate reduction of the tooth to accommodate the needed strength of the porcelain veneer in this area of the preparation.

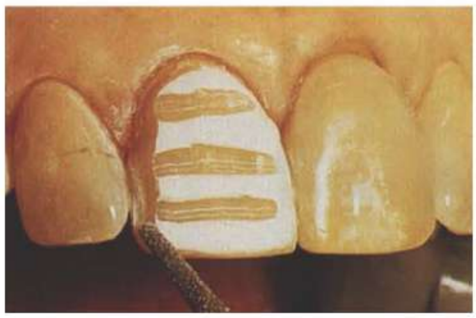


3. Incisal-lapping preparation: is used routinely when defects exist along the lingual aspect of the incisal edge, and when the tooth needs lengthening.

To control the depth of the facial tooth preparation and remain in enamel, self-limiting depth-cutting disks are used to produce horizontal depth guiding grooves. These depth-cutting disks permit 0.3-mm, 0.5-mm, and 0.7-mm cuts to be placed on the facial surface at the gingival, middle, and incisal thirds respectively.

Supragingival finish line is indicated over subginigival one unless correcting severely discolored teeth. A long, tapered, round-end diamond bur is used to prepare a definitive chamfer (0.3 to 0.4 mm depth), uniformly 0.5 mm supragingival from the gingival margin.

Begin at the height of the free gingival margin and prepare the chamfer margin to the distal papilla tip. Then prepare the chamfer margin to the mesial papilla tip. Continue the definitive chamfer finish line from the distal papilla tip to the beginning of the contact area, far enough lingually, to hide the veneer margin when viewed from the side of the tooth. The same type of definitive chamfer is placed from the mesial papilla tip to the end of the incisal embrasure.

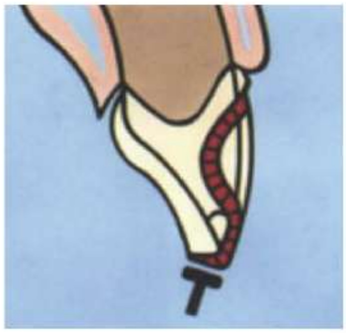


The proximal margins should be extended to the interproximal contact point without breaking it, so that there is an interproximal finish line. In the presence of diastemas, proximal coverage is recommended.

The facial reduction must be performed in three different inclinations (cervical, middle, and incisal thirds). As the mark disappears, it becomes apparent that the desired depth has been reached.

Incisal reduction of 1.0 to 1.5 mm should be performed with a roundend tapered bur, slightly inclined to the palate. The diameter of the bur will guide the depth of reduction. A disc bur could be used also for incisal reduction.

The reduction of the incisal table should not be done perpendicular to the long axis of the tooth but about 30° to 40° off perpendicular toward the lingual. This slight angulation toward the lingual provides resistance form against porcelain edge fracture and a sharp finish line for the ceramist to form a porcelain butt margin against. The facioincisal angle, which becomes sharp from the facial reduction, must now be rounded off or it will create an area of stress under the veneer.



Clinical procedures for inlay and onlay

Correct tooth preparation for ceramic inlays and onlays is critical to achieving a lasting restoration. Based on the knowledge of the ceramic material properties, adhesive cementation, and clinical experience, the divergent relatively non-retentive preparation is most commonly advocated for easier placement of the restoration. Thus, the principles of cavity preparation for esthetic inlays and onlays differ from those for gold restorations.

because the restoration is adhesively bonded and also very little pressure can be applied during try-in and cementation.

Because of the inherent fragility exhibited by ceramic material, three primary requirements are important when preparing a tooth for ceramic restorations of this type: (1) avoidance of internal stress concentration areas, (2) provision for adequate thickness of ceramic, (3) creation of a passive insertion axis.

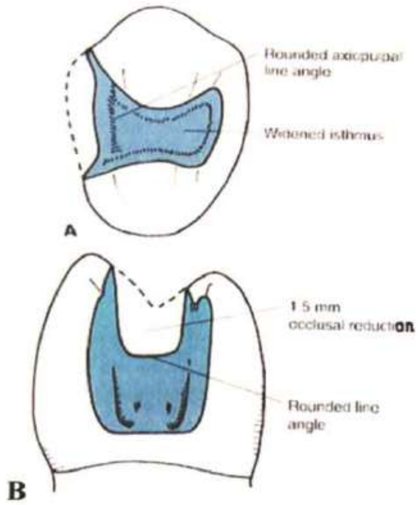
Internal stress concentrations can be avoided by eliminating undercuts of the prepared surface, ensuring that the wall and floor of the preparation are smooth and even, and by rounding internal line and point angles.

Ceramic strength is proportional to its thickness but only up to a certain point. A study has shown that ceramic thickness greater than 2 mm, increases the risks of pulp damage (deeper preparation) without significantly enhancing the restoration fracture strength. Therefore, a uniform 2 mm occlusal thickness is considered ideal for ceramic inlays and also for onlays involving functional cusps.

Before tooth preparation and as the first clinical step, the patient is anesthetized and the area is isolated, preferably using rubber dam, and the carious lesion should be completely excavated and/or the compromised restoration (if present) should be completely removed.

Occlusal preparation

Carbide or diamond burs used for tooth preparation should be tapering instruments that create occlusally divergent facial and lingual walls.

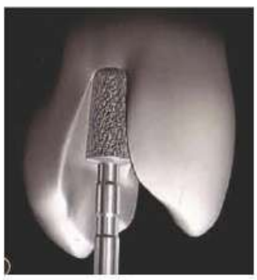


To ensure a uniform ceramic thickness, the occlusal preparation floor must present a shallow V shape following the anatomy of the surface. No need for extending the preparation further than the initial defect.

Axial reduction allowing a uniform thickness of 1.5-2 mm for the restoration is sufficient for any of the currently used ceramic systems.

Cavity walls should be flared 5 degrees to 15 degrees in total (10 degrees to 12 degrees ideal), (which is greater than that used for cast metal which is 2° to 5° per wall).

All line angles (internal and external) should be rounded to avoid stress concentrations in the restoration and tooth, reducing the potential for fractures. Isthmus should have a minimum width is 2 mm to avoid ceramic fracture. Areas prepared closer than 0.5 mm to the pulp should be lined with calcium hydroxide, and undercuts should be filled with an appropriate liner or base.



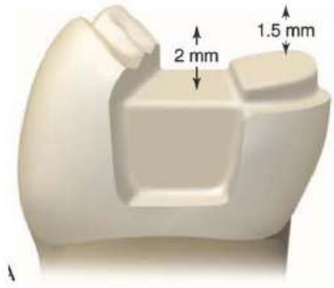
Unlike gold and metal inlays and onlays, bevels are not indicated. All margins should have a 90-degree butt-joint cavosurface angle to ensure marginal strength of the restoration. A 90-degree butt-joint minimizes the chipping problem of ceramic material.

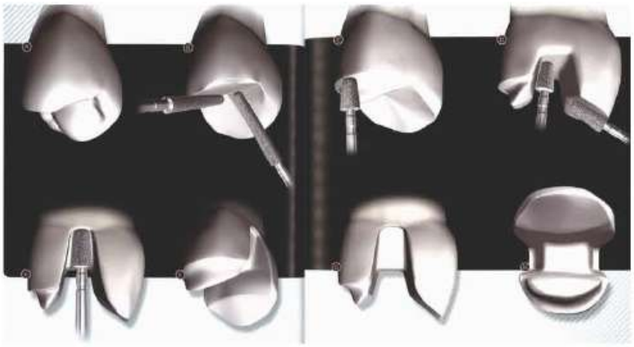
Since the retention of ceramic restoration rely on adhesive cementation, no retentive preparation forms are needed (unlike metal inlay and onlays which may necessitate these forms which include grooves, pin holes, and dove tails).

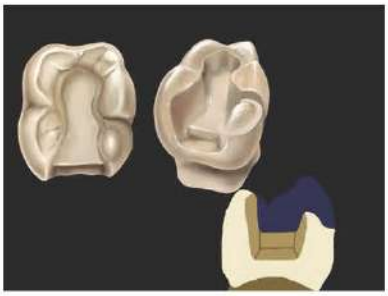
Cusp preparation

For onlay restorations, nonworking and working cusps are covered with at least 1.5 mm and 2 mm of material, respectively. If the cusp to be onlayed shows in the patient's smile, a more esthetic blended margin is achieved by a further 1- 2 mm reduction with a 1 mm chamfer.

When the occlusal aspect of the cavity is prepared, undercuts should not be eliminated by removing healthy tooth structure, which compromises the conservatism of this approach. The objective is to establish divergence in the enamel, then block out all undercuts. This is possible using bonded resin or a resin-modified glass ionomer.



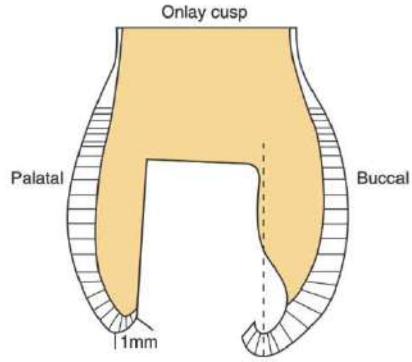




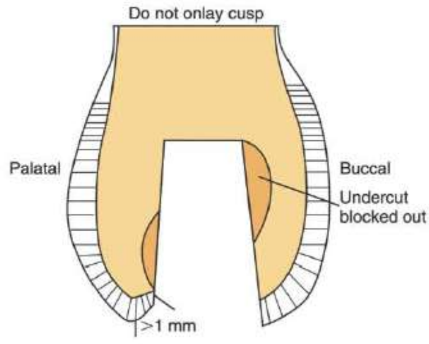
When to overlay the cusp?

The more unfavorable the cavity situation, the more the clinician has to consider cutting and covering the cusps to prevent possible coronal fractures. Generally, if the cuspal thickness of the vital tooth (measured at the thinnest point and in axis with the cuspal apex) is less than 2 mm, a cuspal coverage is suggested. For non-vital posterior teeth, the thickness limit is 3 mm.

For cemented castings it is generally best to overlay a working cusp when the cavosurface margin is more than 50% up the incline of the cusp. The cavosurface margin can extend up to 75% up the cuspal incline of a nonworking cusp before overlaying of the cusp is considered. Studies have investigated the use of bonded inlay or onlay restorations for this area, but no clinical



consensus on when to remove a cusp has been reached. Because these restorations reinforce the remaining tooth structure, the traditional guidelines for overlaying a cusp as in cast gold onlays have been modified. When there is no dentin support directly underneath the cusp tip, the cusp should be onlayed. The palatal or working cusp is onlayed, even with dentin support if the margin is within 1 mm of the cusp tip. When the margin is beyond 1 mm from the cusp tip, the cusp gains dentin support and bond strength increases.



The horizontal lines depict the direction of the enamel rods. At the cusp tip the enamel rods are almost vertical and etching would be on their sides. As the margin moves away from the cusp tip the ends become etched, which has been shown to increase bond strength.

The non-working or buccal cusp is not onlayed even when the margin is at the cusp tip. If the posterior teeth are discluded in lateral jaw movements, there are no forces applied to this cusp.

It is not uncommon to find cracks on the pulpal floor under cusps when removing amalgams that have been in place for some time, particularly moderate-sized ones. Whether the teeth exhibit pain on chewing (e.g., cracked tooth syndrome) or are asymptomatic, these cusps should be overlayed.

Logic also dictates that for patients with parafunctional habits (e.g., bruxism or clenching) the cusps should be overlayed more aggressively.

Types of preparation

1. Butt joint preparation

The butt joint requires minimal preparation and is therefore suitable for adhesive techniques. It is represented by an occlusal reduction that follows the evolution of the cusps and the main sulcus, so is generally flat but with an inclined surface. At the level of the finishing line, the butt joint should have an inclined trend toward and follow the occlusal surface, which is then made more horizontal.

Indications for a butt joint preparation:

a. Cuspal reduction to protect the teeth from the occlusal load.
b. Cuspal fracture in the area of the occlusal third (or middle third, in some cases).
c. Presence of strong abrasions/erosions of the occlusal surface (with the possibility of increasing the vertical dimension).

2. **The bevel preparation**

It is similar to the butt joint but with the substantial difference of the presence of an inclined bevel, generally of 45 degrees or more, for an average length of 1 to 1.5 mm, which can be more extended in exceptional cases. This beveling is generally present on the buccal side, but can also be on the palatal side (eg, in cases where the cracking of the enamel within the preparation should be included or when more thickness and support is required for a restoration on a working cusp). Where there is a bevel on the whole circumference, the variant of a full bevel can be considered.

Indications for a bevel preparation:

a. Esthetic need for a more gradual integration of the restoration-tooth transition.
b. Wider surface of external enamel, which enhances adhesive cementation procedures.
c. To create more space for the restoration in the peripheral zone.

3. **The shoulder preparation**

The shoulder is a preparation characterized precisely by a rounded shoulder, which develops on the peripheral part of the design. The central part is generally represented by the build-up (or block out), usually made of a resin- based material. The thickness of the shoulder is about 1 mm, thus allowing for the largest possible enamel thicknesses that enhance adhesive cementation procedures. The management of the finishing line must be realized with a geometrically determined bur, with a slightly tapered shape and a rounded inner corner.

Indications for a shoulder preparation:

a. Previous cuspal fracture to the cervical third (or middle third in some cases), and then, by effect, the central build-up automatically defines the peripheral shoulder design.
b. Where a greater structural protection is required for a cusp coverage with a cervical grasp.

Proximal box preparation

In the preparation of ceramic inlay, variations exist that may or may not involve the proximal walls turning it into MO or DO preparation. Attention should be paid to preserving the marginal ridges in case there is no need to involve them.

For the preparation of proximal box, the adjacent tooth should be protected with a metal strip, removing the contact point. The reduction is deepened by 2/3 of the coronal height in the gingival direction, ensuring that the isthmus has a minimal width of 2 mm to provide adequate resistance to the restoration. The gingival margins of proximal box should extend as minimally as possible because margins in enamel are generally preferred for bonding. The margins should be prepared with a butt joint.

Dr. Mohammed Ayad

Lecture (21)

Operative Dentistry

CAD/CAM Techniques

The computer-aided design and computer-aided manufacturing (CAD/CAM) system is a technology in which the planning and production of prostheses are carried out with the aid of a computer. CAD/CAM were developed in the 1960s for use in the aircraft and automotive industries. Dr. Francosis Duret produced the first CAD/CAM dental restoration in 1983 and in 1987 Mörmann and Brandestini discovered CEREC system, which was the first dental system to combine digital scanning with the milling unit.

All CAD/CAM systems consist of three components:

1. A digitalization tool that is responsible for data collection from the area of the prepared teeth with adjacent and opposing areas through intra-oral or extra- oral scanners which then converts them to virtual impressions.
2. Software that processes data and, depending on the application, produces a data set for the product to be fabricated.
3. A production technology that transforms the data into the desired product.

Despite the improvement in the impression materials, conventional impression making is still considered uncomfortable for the patient and time consuming for the clinician. With the introduction of CAD/CAM technologies in the late 1980s and the development of intra-oral scanning devices during the past 20 years, alternatives to conventional impression making exist.

Digital impression

Four types of imaging technology are currently employed in the optical scanners which determine the measurement speed, resolution and accuracy of the scanner. These imaging technologies are: (i) Triangulation, (ii) Parallel confocal imaging, (iii) Active wave front sampling and (iv) Three-dimensional in-motion video.

Intra-oral digital impression

Intra-oral digital impression, also known as "direct digital impression", is a method that replicates the intra-oral situation using a 3-D camera to capture the data in a digital format and then generate a virtual model. The restorations can be then designed on the basis of the virtual model by the computer software. Finally, restoration manufacturing is proceeded with the milling machine.

Direct intra-oral digital impressions can avoid errors more than a conventional impression can do. Additionally, intra-oral digital scanning can save time and steps for both dentists and technicians. Steps eliminated at the dental office include tray selection, material dispension, impression disinfection and impression packaging and shipping. Steps eliminated at the dental lab include plaster pouring, die cutting, trimming, articulation and extra-oral scanning.

It has been found that the intra-oral digital impressions and scanning systems increase the patient's level of comfort and treatment acceptance, especially with some patients who experienced gag reflex during conventional impression taking. Moreover, digital impression reduces the distortion of the impression material and provides the opportunity of improved 3-D pre-visualization of tooth preparation.

Despite the previous advantages of digital intra-oral impression method, one should consider the limitations of this technique that include finish line location, periodontal health, saliva flow rate and sulcus bleeding during impression taking. These limitations are due to the fact that the camera can only record what is visible to the camera lens; therefore, structures or margins obscured by saliva, blood, or soft tissue are not visible to the camera and will not be accurately recorded.

Additionally, the accessibility of the preparation for the scanner wand is critical, which can be diminished in the retro-molar region especially in patients with limited mouth opening or an ascending ramus of the mandible situated close to the buccal surface of the last molar.

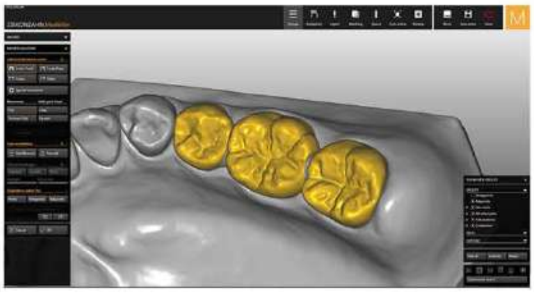
Extra-oral digital impression

Extra-oral digital impression, also known as, "indirect digital impression" or "die scanning technique", is a laboratory procedure that requires a conventional stone model to begin the CAD/CAM process.

Prior to the extra-oral digitization, an impression of the clinical situation has to be taken. After pouring the impression, the resulting cast model is scanned extra-orally by using an optical or mechanical scanner. A 3-D virtual image is displayed on the computer monitor and the restoration is designed and fabricated from the digital data obtained.

Data processing software (design software)

It is a computer unit with a software package for visualization of the scanned data, planning and designing dental restorations on a computer screen. Softwares collect data in the "Standard Transformation Language (STL)" or so called "Standard Tessellation Language" format. It is possible to design a variety of dental restorations such as veneers, inlays, onlays, individual crowns, bridges, copings and partial denture frameworks.



When the design of the restoration is complete, the CAD software transforms the virtual model into a specific set of commands, which in turn drive the CAM unit to fabricate the designed restoration.

Production technology

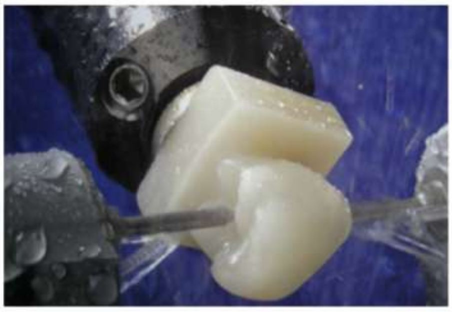
The final stage of computer-aided manufacturing (CAM) can be divided mainly into two main groups according to the technique used: subtractive or additive manufacturing technique. An additional technique (hybrid technique) has been developed combining both techniques.

Subtractive manufacturing technology

This technique is based on milling the product from a block by a computer numeric controlled (CNC) machine. The CAM software automatically transfers the CAD model into a tool path for the CNC machine. This involves computation of the commands series that dictate the CNC milling, including sequencing, milling tools, and tool motion direction and magnitude.

The milling units can be classified according to the number of milling axes into 3-axes, 4-axes, and 5-axes devices.

They also can be classified according to the processing technique into dry milling (applied mainly to zirconium oxide blanks with a low degree of pre-sintering to avoid moisture absorption by the die ZrO2 mold), and wet milling (cool liquid spray is used to protect diamond or carbide cutter tool against the heating of the material in the milling. This type is used for metals, glass ceramic, and pre-sintered zirconium oxide).



Additive manufacturing technology

Additive manufacturing (known as 3D printing) refers to technologies that build physical objects directly from three-dimensional CAD data. This technique adds liquid, sheet, wire or powdered materials, layer-by-layer, to form parts with little or no subsequent processing requirements. This approach provides several advantages, including nearly 100% material utilization, short production times and remarkable geometric freedom of design.

Dr. Mohammed Ayad

Lecture (22)

Operative

Fluoride – Releasing Materials

Introduction

Caries is the most prevalent non-communicable disease in the world. It is a multifactorial disease with a bacterial etiology. Dental caries results from bacteria that metabolize sucrose or other cariogenic sugars (fructose and glucose) and secrete organic acids (lactic, propionic, and formic) that cause the loss of mineral ions (calcium and phosphates) from the tooth (demineralization). Minerals lost by this method can be replaced during periods of neutral pH (remineralization) from calcium and phosphates in the saliva. The availability of fluoride ions enhances remineralization and prevents demineralization of dental hard tissue.

High-risk patients need specialized treatment before, during, and after definitive restorative care. Fluoride is an important adjunct in caries prevention. In addition to professionally applied fluorides and fluoride-containing dentifrices, fluorides may be introduced into the oral environment with fluoride-releasing restorative materials. All fluorides act to slow demineralization and boost remineralization. If not toggled, bacteria continue destroying tooth structure, eventually infecting the soft pulp tissue and causing pain and pulp necrosis.

Fluorides work in at least four different ways to protect teeth from tooth decay:

1. Inhibition of demineralization:

The fluoride binds calcium and phosphate ions, present in dental hard tissue (enamel), that dissolve as a result of the acid penetration (acid attack from bacteria of dental plaque) into the dental tissue.

2- Enhancing remineralization:

The fluoride from topical sources (pastes and varnishes) enhances remineralization of the partially demineralized dental tissue by speeding up the growth of new surface on the partially demineralized subsurface crystals in the caries lesion, fluoride adsorb to the crystal surface and attracts calcium ions followed by phosphate ions leading to the new mineral formation and growth of the crystals.

3- Antimicrobial action:

Fluorides interfere with the bacteria that cause decay that colonizes teeth and reduce their acid production by reducing carbohydrate metabolism, thus slowing the demineralization of dental hard tissue.

Restorative materials that release fluoride are often recommended for caries on root surfaces because root structure is primarily composed of dentin and these lesions require significantly greater amounts of fluoride than enamel caries lesions to promote remineralization.

Materials that release fluoride

Fluoride-releasing materials may be classified based on similarities in physical, mechanical, and setting properties. However, the ability of each material to release and uptake fluoride ranks from superior such as GIC to inferior such as resin composite

These materials include:

Fluoride Varnish:

Fluoride varnish is effective in preventing caries on permanent teeth. Fluoride varnish also has recently been shown to prevent or reduce caries in the primary teeth of young children.

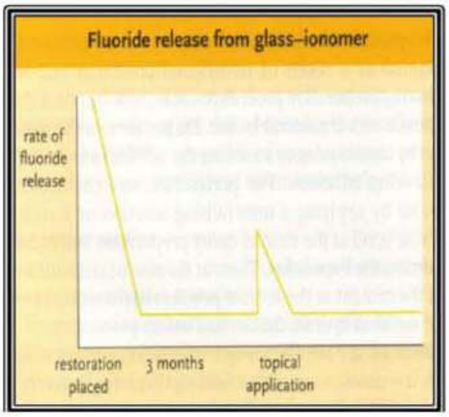
How is the varnish applied?

Application is quick and easy: small droplets of varnish are applied directly to the tooth surface.

Glass ionomer cement:

Glass ionomer cement are material consisting of ion-cross-linked polymer matrices surrounding glass-reinforcing filler particles. Glass ionomer cement for restorations was based on a solution of polyacrylic acid liquid that was mixed with a complex alumino-silicate powder containing calcium and fluoride. The acidic liquid solution (PH ≤ 1.0) dissolved portions of the periphery of the silicate glass particle releasing calcium, aluminum, fluoride, silicon, and other ions.

This process generates true chemical bonds at all internal and external interfaces (tooth surface-filling) when the reaction conditions are correct. Set materials have modest properties compared with composite but have relatively good adhesion and the ability to release fluoride ions from the matrix for incorporation into neighboring tooth structures to suppress dental caries.



- Initial release is high. But **declines after 3 months.**

After this, fluoride release continuous for a long period.

- Fluoride can also be taken up into the cement during topical fluoride treatment and released again, thus GIC act as **fluoride reservoir.**

Their main characteristics are:

1. An ability to chemically bond to enamel and dentine with insignificant heat formation or shrinkage.
2. Biocompatibility with the pulp and periodontal tissues.
3. Fluoride release produces a cariostatic and antimicrobial action.
4. Less volumetric setting contraction; and a similar coefficient of thermal expansion to tooth structure.

These advantages have made them successful as luting cement and lining materials. However, as a restorative material, their sensitivity to moisture, low esthetic, mechanical strength and wear resistance make them the least durable. This may be adequate for primary teeth because they will exfoliate in several years.

Resin-modified glass ionomer cement:

The simplest forms of resin-modified glass ionomer cement contain the addition of a small number of resin components such as hydroxyethyl methacrylate (HEMA) in the liquid of conventional glass ionomers. More complex materials have been developed by modifications of the polyacid with side chains that can be polymerized by a light-curing mechanism.

Their main characteristics are:

1. Glass ionomer cement bonds chemically to enamel and dentine with insignificant heat formation or shrinkage of material during the hardening reaction. So that the cement can firmly adhere to both enamel and dentine without signs of marginal leakage.

2. The shear bond strength of the resin-modified cement to dentine is significantly higher than that of conventional glass ionomer cement and the bond is a stable one.

3. Resin-modified glass ionomers have the advantage of being able to directly bond to resin composite, making them useful in glass ionomer/composite laminate restorations.

4. The resin-modified glass ionomers are also highly biocompatible to the pulp and it has better adaptation and seal to the cavity preparation than conventional glass ionomer materials.

5. The final set structure shows a dramatic increase in compressive strength but is rather brittle and comparatively low in tensile strength and has low abrasion resistance making it unsuitable for high stress-bearing areas such as posterior teeth.

6. The fluoride release from and uptake by the resin-modified products was higher than or the same as that of conventional glass ionomers and has no adverse effect on the bond strength.

7. resin-modified glass ionomers have greater curing shrinkage than conventional chemically-cured cement. Incremental placement techniques should always be used to ensure complete curing at depth and to minimize polymerization shrinkage.

Clinical use

Usually comes as a two-paste system, and can harden without light-curing. It has a longer working time. It sets sharply once the polymerization reaction is initiated by light. Most manufacturers state that immediate polishing can be carried out after light-curing. However, the setting reaction will continue slowly for at least 24 hours and the best result can be obtained if finishing is delayed. When immediate polishing is required, care must be taken not to overheat the restoration as this may cause excessive drying and cracking and may prevent the setting of the ionomeric component. Highly desirable, alternative to amalgam for restoring primary teeth, and as a liner/base material.

Polyacid-modified resin composites (compomers)

Recently, other resin-ionomer hybrid restoratives have been marketed as multipurpose materials or are resins that may release fluoride but have only limited glass ionomer properties. One such new material is the 'compomer' which contains the major ingredients of both composites (resin component) and glass ionomer cement (polyalkenoate acid and glass fillers component) except for water. The fluoride release from compomers has been demonstrated, more than composite but at a lower level than that of GICs. Although low, the level of fluoride release has been reported to last at least 300 days.

Their main characteristics are:

1. It has two different mechanisms responsible for the formation of adhesive bonds to the cavity wall. One of these is the self-adhesive property of the restorative itself, it can bond to both enamel and dentine without acid etching by carboxyl (-COOH) groups, and the functional carboxyl groups can form ionic bonds with the calcium ions of the tooth surface. The second mechanism is adhesion to the tooth surface through the primer/adhesive system.
2. Can only be hardened through light-curing.

3. It has a significantly lower bond strength to dentine than other resin-modified glass ionomer cement and chemically cured glass ionomer.
4. Often one component with an adhesive system.
5. Little is known about the clinical wear performance on the recently marketed compomer restorative materials.
6. Recently, studies have found that the release of fluoride by compomers was significantly less than resin-modified glass ionomer cement or other fluoride-releasing resin composites. However, the antibacterial action decreased significantly over time. In addition, the caries inhibition effect of compomer restorative material was higher than the conventional type of resin composite.
7. The radiopacity of compomers differs from that of dentine and it is slightly higher than that of enamel. This value is considered to be desirable for the radiographic detection of recurrent caries and offers an easy method for documentation of dental work.

Clinical use:

Ease of manipulation is another advantage of the compomer restoratives. Similar to resin composites, since the adhesive can provide sufficient bond strength for retention, no acid etching procedure is required before placement of the restorative. The consistency makes it easy to apply and contour without stickiness and, therefore, less time will be required for final finishing. These properties are especially beneficial in treating children because restorations usually can be completed much faster and within the tolerance of the child patient.

A recent study has shown that curing shrinkage is similar to that of conventional hybrid resin composites. Therefore, placement in increments of 3 mm or less is recommended for Dyract AP, 2 mm or less for other newer compomers, and then each to be cured for at least 40 seconds. Finishing can be undertaken immediately after curing using fluted tungsten carbide finishing burs or polishing discs.

They may or may not have the typical features of true glass ionomers such as chemical adhesion to tooth structures and long-term fluoride release. Therefore, they should be used carefully, and closely following the instructions of the manufacturers because different handling methods may influence their clinical behavior. It is used as a liner/base, restoration, and fissure sealant.

Giomer

A newer product category called "giomer" has been proven in many research studies to overcome the weakness of compomers which are often technique sensitive, have limited fluoride release, and are affected by water sorption which decreases physical properties with time. Giomer is a tooth-colored restorative material that uses a resin base and pre-reacted glass ionomer (PRG) technology.

S-PRG technology delivers some properties of glass ionomer such as fluoride release and recharge which helps prevent caries recurrence. It also provides properties of composite resin such as excellent aesthetics, easy polishability, biocompatibility and smooth surface finish. Moreover, it has an antiplaque effect by forming a material film layer with saliva that is reported to minimize plaque adhesion and inhibit bacterial colonization. Giomers report comparable microleakage scores to that of composite resins in permanent teeth.