Endodontics

Lecture 1 م. م. عثمان هشام العاني

Introduction and Scope of Endodontics

Endo is a Greek word for “Inside” and Odont is Greek word for “Tooth". Endodontic treatment treats inside of the tooth. Endodontics is the branch of clinical dentistry associated with the prevention, diagnosis and treatment of the pathosis of the dental pulp and peri-radicular tissue.

OBJECTIVE OF ENDODONTIC TREATMENT

The primary objective of endodontic therapy is to create a biologically acceptable environment within the root canal system which allows the healing and continued maintenance of the health of the peri-radicular tissue. This objective can be achieved by eliminating the bacteria (source of infection) from within the root canal system, and sealing the root canal and tooth to prevent re-infection. Since nothing is as good as the natural teeth, one should take care of them.

The endodontic therapy is a necessary treatment to cure a damaged or diseased tooth. Endodontics has been defined as art as well as science of clinical dentistry because in spite of all the factual scientific foundation on which the endodontics is based, to provide an ideal endodontic treatment is an art in itself.

Endodontic treatment encompasses procedures that are designed to maintain the health of all or part of the dental pulp. When the dental pulp is diseased or injured. treatment is aimed at preserving normal peri-radicular tissues. When apical periodontitis has occurred treatment is aimed at restoring the peri-radicular tissues to health: this is usually carried out by root canal treatment, occasionally in combination with surgical endodontics.

SCOPE OF ENDODONTICS

Scope of endodontics includes following:

a. vital pulp therapy (pulp capping, pulpotomy) .

b. Diagnosis and differential diagnosis of oro-facial pain.

c.Root canal treatment of teeth with or without periradicular pathology of pulpal origin.

d. Surgical management of pathology resulting from pulpal pathosis.

e.Management of avulsed teeth (replantation)

f.Root end resections, hemisections and root resections

g.Retreatment of teeth previously treated endodontically

h.Bleaching of discolored teeth.

i.Coronal restorations of teeth using post and cores

INDICATIONS FOR ROOT CANAL TREATMENT

Root canal treatment may be carried out on all patients where other dental procedures may be undertaken. Specific indications are

1. An irreversibly damaged or necrotic pulp with or without clinical and/or radiological findings of apical periodontitis.

2. Elective devitalization, e.g. to provide post space, prior to construction of an overdenture, doubtful pulp health prior to restorative procedures, likelihood of pulpal exposure when restoring a (misaligned) tooth and prior to root resection or hemisection.

CONTRAINDICATIONS FOR ROOT CANAL TREATMENT

1 . Teeth that cannot be made functional nor restored.

2. Teeth with insufficient periodontal support.

3. Teeth with poor prognosis, uncooperative patients or patients where dental treatment procedures cannot be undertaken.

4. Teeth of patients with poor oral condition that cannot be improved within a reasonable period.

ANATOMY OF DENTAL PULP

Pulp lies in the center of tooth and shapes itself to miniature form of tooth. This space is called pulp cavity which is divided into a pulp chamber and root canal/s starting from the orifice to the apical foramen. There are also accessory and lateral canals. The roof of pulp chamber consists of dentin covering the pulp chamber occlusally. Canal orifices are openings in the floor of pulp chamber leading into the root canals. The shape of root canal varies with size, shape, number of the roots in different teeth.

FUNCTIONS OF PULP

Pulp performs four basic functions:

. 1. Formation of dentine

2. Nutrition of dentine

3. Innervation of tooth

4. Defense of tooth

ROOT CANAL CONFIGURATION

The shape of root canals is divided into four types:

Type 1: A single canal leaving the pulp chamber and continuing as a single canal to the root apex and opens in a single apical foramen. It refers to 1-1-1

Type 2: Two canals leave the pulp chamber then join each other at the apical third to open in a single apical foramen. It refers to 2-1 -1

Type 3: Two canals leave the pulp chamber and continue as two canals to be opened in two separate apical foramina. It refers to 2-2-2

Type 4: A single canal leaving the pulp chamber, and bifurcating at the apical third into two canals and open in two apical foramina. it refers to 1-2-2 .

***Lateral canal:** Is a canal that is located approximately at right angle to the main root canal. Lateral canals are clinically significant; like the apical foramen, they represent pathways along which disease in the pulp may extend to periradicular tissues and occasionally allow disease in periodontium to extend to the pulp.

***Accessory canal:** Is one that branches off from the main root canal, usually located somewhere in the apical region of the root.

Accessory and lateral canals connect the pulp to the periodontal tissue, but many of these canals are sealed by cementum and/or dentin, however many remain viable which make them a source of spread of infection even after successful debridement of the main canal. Accessory canals can be exposed by removal of cementum during scaling and root planning, which establishes a communication between the oral cavity and the pulp, which can lead to necrosis

***Apical foramen:** It is a foramen at the apex of each root through which blood vessels, nerves and lymphatic that supply the pulp enter. The location and the shape of the apical foramen may undergo changes as a result of functional influence on the teeth.

BASIC PHASES OF TREATMENT

There are three basic phases of treatment:

1-The Diagnostic phase in which the disease to be treated is "determined "and the treatment plan developed.

2-The Preparatory phase in which the contents of the root canal are removed and the canal is prepared to receive a filling material.

3- The obliteration Phase in which the canal is filled or obliterated with an inert material to obtain an adequate seal as close as possible to C.D.J. (cementodentinal junction).

If there is a defect in any phase, the endodontic treatment will not be succeeded.

Who performs an endodontic therapy ?

Generally, all dentists receive basic education in endodontic treatment but an endodontist is preferred for endodontic therapy. General dentists often refer patients needing endodontic treatment to endodontists.

Why does patient Feel Pain?

When pulp becomes infected. it causes increased blood flow and cellular activity, and pressure cannot be relieved from inside the tooth. This causes pain. Pulp can even die without causing significant pain; it may depend on pain threshold and pain reaction of the patient.

How can You Tell if Pulp is infected?

when pulp gets inflamed, it may cause toothache on taking hot or cold, spontaneous pain, pain on biting or on lying down. On occasion a damaged pulp is noticed by drainage, swelling, and abscess at the root end (Fig. 2). Sometimes, however, there are no symptoms,

Why does patient Need Root Canal Therapy

Because tooth will not heal by itself, the infection may spread around the tissues causing destruction of bone and supporting tissue. This may cause tooth to fall out. Root canal treatment is done to save the damaged pulp by thorough cleaning and shaping of the root canal system and then filling it with gutta-percha (rubber like) material to prevent reoontamination of the tooth. Tooth is permanently restored with crown with or without post.

What are Alternatives to Root Canal Therapy ?

If tooth is seriously damaged and its support is compromised, then extraction is only alternative.

What is Root Canal Treatment Procedure?

Once the endodontic therapy is recommended, your endodontist will numb the area by injecting local anesthetic. After this a rubber sheet is placed around the tooth to isolate it. Then the opening is made in the crown of the tooth and very small sized instruments are used to clean the pulp from pulp chamber and root canals (Fig. 2). After thorough cleaning and shaping of root canals (Fig. 3), they are tilled with rubber like material called guttapercha. which will prevent the bacteria from entering this space again (Figs 4 and 5). After completion of endodontic therapy, the endodontist places the crown or other restoration so as to restore the tooth to full function (Fig. 6).

Will the Tooth Need An Special Care or Additional Treatment after Endodontic

Treatment?

Patient should not chew or bite on the treated tooth until the patient has had a tooth restored

by the dentist. The non-restored tooth is susceptible to fracture. so patient should visit the

dentist for a full restoration as soon as possible not more than one month. Most endodontically treated teeth last as long as other natural teeth. In a few cases, a tooth that has undergone endodontic treatment does not heal or the pain continues. Occasionally, the

tooth may become painful or diseased months or even years after successful treatment. Often when this occurs. re-treating the endodontic procedure can save.

Can All Teeth be Treated Endodonticall ?

Most of the teeth can be treated endodontically. But sometimes when root canals are not accessible, root is severely fractured, tooth cannot be restored or tooth doesn’t have .sufficient bone support it becomes difficult to -.-treat the' tooth endodontlcally However; ‘. :l: advances In endodont‘cs ‘ar'e Fnaklng "tt possible sz" save the teeth that evena few years agowould have been lost. NeWer researches, techniques and materials have helped us to perform the endodontic therapy in better way with more efnciency Since Introduction of rotary instruments and other technologies reduce the treatment time the concept of single VISIt IS gaming popularity nowadays. It has been shown that success of endodontic therapy depends on the quality of root canal treatment and not the number of vusnts In the modem world, single visit endodontics is becoming quite popular

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PULP AND PERI-RADICULAR PATHOLOGY

Etiology of pulpal diseases can be broadly classified into:

I. Bacterial irritant

Bacteria, usually from dental caries, are the main source of injury to the pulpal and periradicular tissues and they enter either directly or through dentine tubules.

Modes of entry for bacteria to the pulp are as follows:

1-Through the carious cavity.

2-Through the dentinal tubules as in contamination during cavity preparation, through exposed root surface, and surfaces with erosion, abrasion and attrition.

3-Through the apical foramen as in advanced periodontitis where microorganisms reach the apical foramen and then the pulp.

4-Through the blood stream (anachoresis: it is a process by which microorganisms get carried by the bloodstream from another source localize on inflamed tissue). Following trauma or inflammation to the pulp any bacteria in the blood might be attracted to the pulp causing pulpitis.

5-Through faulty tooth restoration.

6-Through extension of a periapical infection from adjacent infected tooth.

Bacteria most often recovered from infected vital pulps are:

.Streptococci

.Staphylococci

. Diphtheroids, etc.

II. Mechanical irritants

Examples of mechanical irritation include trauma. operative procedures, excessive orthodontic forces, subgingival scaling and overinstrumentation using root canal instruments.

Ill. Chemical irritants

Pulpal irritation may result from bacterial toxins or some restorative materials/conditioning agents.

Peri-radicular_ irritation may occur from irrigating solutions, phenol-based intra-canal medicaments orextrusion of root canal filling materials.

IV. Radiation iniury to pulp

Radiation therapy affect pulps of fully formed teeth in patients exposed to radiation therapy. The pulp cells exposed to ionizing radiation may become necrotic, there may occur vascular damage and the interference in mitosis of cells.

Classification of Pulp Disease

Diagnosis of pulp disease is usually based on patient symptoms and clinical findings. Pulpal disease may result in changes to both the soft and hard tissues.

❖ **Soft tissue changes**

Reversible pulpitis (Pulpal Hyperaemia): It is a transient condition that may be precipitated by any insult (ex. caries) to the pulp and characterised by increase in vascular vasodilation.

The symptoms are usually:

- Pain needs an external stimulus and it subsides immediately after removal of stimulus.
- Pain is difficult to localise (as the pulp does not contain proprioceptive fibers).
- Normal periradicular radiographic appearance.
- Teeth are not tender to percussion but sensitive to cold stimulus.

Treatment involves covering up exposed dentine, removing the stimulus or dressing the tooth.

Irreversible pulpitis: Irreversible pulpitis usually occurs as a result of more severe insults than in the reversible pulpitis. it may develop as a progression from a reversible state.

1) Acute pulpitis: The pulp experiences increased inflammatory process and intrapulpal pressure. The symptoms experienced are:

- Severe pain develops spontaneously or from stimuli which may last from minutes to hours.
- Heat stimulus increases pain due to expansion of blood vessels therefore increasing pressure in the pulp.
- Cold stimulus decreases pain due to contractile action on the blood vessels therefore lowering intrapulpal pressure.
- Not tender to percussion and normal radiographic apical region

- A widened periodontal ligament may be seen radiographically in the later stages.

  Treatment involves either root canal therapy or extraction of the tooth.

  2) Chronic pulpitis: After the acute phase the pulp might enter the chronic phase. The symptoms experienced are:

- Mild to moderate intermittent pain may be tolerated by the patient for long period of time.
- Thermal tests are of little value.
- Tenderness to percussion and radiographic changes are not seen until infection reaches the periapical region.

  Treatment involves either root canal therapy or extraction of the tooth.

- **Hyperplastic pulpitis:** Hyperplastic pulpitis is a form of irreversible chronic pulpitis and is also known as a pulp polyp. It occurs as a result of proliferation of chronically inflamed young pulp tissue. Treatment involves root canal therapy or extraction.

  Pulp necrosis: Pulp necrosis occurs as the end result of irreversible pulpitis; **treatment** involves root canal therapy or extraction.

❖ **Hard tissue changes**

Pulp calcification: Physiological secondary dentine is formed after tooth eruption and the completion of root development. It is a condition in which hardening. or calcification. of pulp tissue results in hypersensitivity and extreme pain because the dental nerves become compressed. A root canal is usually necessary to clear away hardened tissue. Pulp calcification is deposited on the floor and ceiling of the pulp chamber rather than the walls and with time can result in occlusion of the pulp chamber. Pulp calcification may be composed of irregular dentine (true denticle) or due to ectopic calcification of pulp tissue (false denticle). Tertiary dentine is laid down in response to environmental stimuli as reparative dentine where it is deposited directly beneath the path of injured dentinal tubules as a response to strong noxious stimuli. Treatment is dependent upon the pulpal symptomst

Internal resorption: Internal resorption is initiated within the pulp cavity and results in loss of substance from dentinal tissue. Occasionally, pulpal inflammation may cause changes that result in dentinoclastic activity. Such changes result in resorption of dentine; clinically, a pink spot may be seen in the later stages if the lesion is in the crown. Radiographic examination reveals a radiolucency that is seen to be continuous with the rest of the pulp cavity.

Root canal therapy will result in arrest of the resorptive process; however, if destruction is very advanced extraction may be required.

External resorption: External root resorption is not a pulp dystrophy for its origin lies within the tissue of the periodontal membrane space. It is the removal of the mineralized and organic components of dental tissues by clastic cells. In the case of external root resorption, this may be a response that may occur following trauma or orthodontic tooth movement and is called **physiological root resorption**. All other forms of external root resorption are **progressive** and **are called Inflammatory (infective) root resorption** and usually results from luxation injury and is caused by the transmission of bacterial toxins from a devitalized and infected pulp via dentinal tubules to an external resorbed root surface.

Clastic cells are stimulated to the region by inflammatory mediators. A diagnosis of **inflammatory root resorption**, which is characterized radiographically by bowl-like radiolucencies in both the tooth and the adjacent bone, is also diagnostic of an infected and probably totally necrotic pulp.

Treatment: Early root-canal debridement and medication with calcium hydroxide paste is recommended.

Classification of periapical disease

Untreated pulpal infection leads to total pulp necrosis. If left untreated, irritants leak into periapical region forming periapex pathologies. Severity of periapical inflammation is related to microorganisms in root canals and the length of exposure to infecting microorganisms.

Acute apical periodontitis AAP

Acute apical periodontitis is defined as painful inflammation of the periodontium because of occlusal trauma, egress of bacteria from infected pulps, toxins from necrotic pulps, chemicals, irrigants or over instrumentation in root canal therapy. Clinically, the tooth is tender to biting. The distinctive features of AAP are dull throbbing constant pain, it occurs over a short period of time. Cold stuff may relieve pain, whereas heat may exacerbate pain. Widening of the periodontal ligament space may be seen on a radiograph.

Treatment depends on pulpal diagnosis it may range from occlusal adjustment to root canal therapy or extraction.

Chronic apical periodontitis

Chronic apical periodontitis occurs because of pulp necrosis. Affected teeth do not respond to pulp sensitivity tests. Tenderness to biting is usually mild however, some tenderness may be noted to palpation over the root apex, radiographic appearance is varied ranging from minimal widening of the periodontal ligament space to a large area of destruction of periapical tissues. Treatment involves root canal therapy or extraction.

Condensing osteitis

Condensing osteitis is a variant of chronic apical periodontitis and represents a diffuse increase in trabecular bone in response to irritation. Radiographically, a concentric radio_ opaque area is seen around the offending root. Treatment is only required if symptoms/pulpal diagnosis indicate a need.

Acute apical abscess

It is a localized collection of pus in the alveolar bone at the root apex of the tooth, following the death of pulp with extension of the infection through the apical foramen into periradicular tissue. The most common cause of Acute Apical Abscess is invasion of bacteria from necrotic pulp tissue. Symptoms vary from moderate discomfort or swelling to systemic involvement, such as raised temperature and malaise. Teeth involved are usually tender to both palpation and percussion. The tooth is non vital and the pain is being of rapid onset with Readily localized as tooth becomes increasingly tender to percussion.

Radiographic changes are variable depending on the amount of periradicular destruction already present; however, usually there is a well-defined radiolucent area. As in many situations, an acute apical abscess is an acute exacerbation of a chronic situation. Initial treatment of an acute apical abscess involves removal of the cause as soon as possible. Drainage should be established either by opening the tooth or incision into a related swelling. An antibiotic may need to be prescribed, depending on the patient's condition. Once the acute symptoms have subsided, then root canal therapy or extraction may be performed. If the apical abscess is not treated, it will spread to surrounding tissues.

Chronic apical abscess

Chronic periapical abscess is also known as suppurative apical periodontitis, which is associated with gradual egress of irritants from root canal system into periradicular area leading to formation of an exudate. In a chronic apical abscess, the abscess has formed a communication through which it discharges. Such communications may be through an intraoral sinus or, less commonly, extraorally. Alternatively the discharge may be along the periodontal ligament; such cases resemble a periodontal pocket. Usually these communications or tracts heal spontaneously following root canal therapy or extraction.

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Access Opening

Access opening is the cavity that is prepared in the crown of a tooth to obtain adequate and direct access (straight line access) to the apical foramen to ensure free movement of the instruments during pulp extirpation. preparation and obturation of the root canal. Preparing the endodontic access cavity is a critical step in a series of procedures that potentially leads to the three-dimensional obturation of the root canal system. Access cavities should be cut so the pulpal roof, including all overlying dentin is removed.

Objectives of Access Opening

1) To facilitate visualization of all the root canal orifices by removing the pulp chamber and exposure of pulp horns.

2) To provide direct access (straight-line access) to the apical portion of the canal.

3) Conserve sound tooth structure as much as possible to avoid weakening of remaining tooth structure. The outline form of the access cavity must be correctly shaped and positioned according to:

l. The size of the pulp chamber.

II. The shape of the pulp chamber.

Ill. The number of individual root canals and their direction of curvature.

The outline form is affected by the size of the pulp chamber, so access opening for young patients is larger, because the pulp chamber is larger. while in old patients the pulp chamber is smaller.

The finished outline should reflect accurately the shape of the pulp chamber. E.g. in premolars the pulp chamber is oval in cross section so the access opening is oval, elongated buccolingually than mesiodistally (following the pulp chamber shape). Sometimes a modification is needed to get the objective of access opening.

The number of individual root canals and their curvature modifies the outline of the access opening. Sometimes we have to remove part of a cusp of a molar or incisal ridge in order to facilitate better visualization to the root canals.

The dentist must be able to see, locate and reach by the instruments each root canal.

Shape of access openings for each anterior tooth

1-Maxillary Central lncisor: The access opening is triangular. The root is straight, single, large, oval at the beginning, then tapered until it becomes rounded apically. **Average tooth length=22.5mm**

2-Maxilla Lateral Incisor: Similar in shape to the max. central incisor, but smaller in size with: disto-palatal curvature at the apex of the root. **Average tooth Length = 21mm**

3-Maxillary canine: the canal is big and it is wider buccolingually than mesiodistally. At the cervical third the orifice is oval, at the middle third: it is oval.. and in the apical third it is rounded. **Average length=26.5mm**

4-Mandibular Incisors: If we take an x-ray from buccal direction we will had small tiny root canal. But if we take an x-ray film from mesial or distal direction, we will fund large, wide pulp “labio-lingually" with a possibility of two canals one labially and the second one is located lingually, so we have to widen the root canal orifIce “Labiolingually”. **Average length=21mm**

In addition, in the lower incisor, sometimes we have slight curvature in the root apex “to the lingual side” so; there is a possibility of perforation during instrumentation.

5-Mandibular Canine: There is one canal, which is big, and oval in shape, Another root canal may be present lingually to the major root canal but this rarely happens. **Average length=22.5mm**

Access opening of each posterior tooth

1-Maxilla first premolar

Access opening: ovoid and elongated buccopalatally. **Average length=21mm**

The canal shape is wide in buccopalatal direction at cervical portion slight ovoid at mid-root and rounded at apical third.

Canal Orifices: below and slightly central to cusps tips. Multiple canal possibilities

(i) 20% single canal in single root, elliptical or figure (8) in shape. wider buccopalatally than mesiodistally. It may be mistaken as two canals.

(ii) 80%: two canals, either single root with either one or two apical foramenae, or two canals with two separated roots “and the palatal one is longet".

(iii) Rarely there are (3) roots with (3) root canals.

2-Maxillam Second Premolar

- Mostly it has a single root and the‘canal shape is ovoid and very wide in buccopalatal direction, ovoid in the mid root, and rounded in the apical area. **Average Length=21.5mm**

-Canal orifice is centrally located and often appears as a slot than as a single ovoid opening.

-Multiple canals possibilities: 40%= 2 canals, 60% = one canal.

3-Mandible First Premolar:

Mandibular first premolar has well developed buccal cusp and a small lingual cusp, the root is more rounded than mandibular second premolar and shorter. The pulp chamber is ovoid and buccal pulp horn higher. **Average length=21.5mm**

-Canal shape: At cervical level is wide in buccolingual dimension. At the mid-root area it is ovoid and at the apical third it is rounded.

-Canal configuration possibilities: Type I = 73.5%, Type II = 6.5%, Type III =19.5% We may also see Type IV.

-Access opening: ovoid and made slightly buccally to the central groove and the final preparation should have a slightly lingual inclination.

4-Mandibular second Premolar:

It has a well developed buccal cusp and much less formed lingual cusp. There is a one root canal, and the pulp chamber is gradually merging with root canal. **Average length=22.5mm**

Canal orifice:

a-At cervical wide in buccolingual dimension.

b-Mid-root level > elongated ovoid.

c-Apical third level > generally round.

5-Maxillaty 1st molar

-There are three roots, with three root canals mesiobuooal distobucoaLand palatal canal which IS the biggest one. **Average length=21mm**

-The final preparation of the access opening is triangular in shape and there are three canals:

a-Mesiobuccal canal: It is a tiny canal, difficult to tind. It is possible to fInd another mesiobuccal canal (70%) lingual to the main one.

b-Distobuccal canal: It is toward the distopalatal side.

c-The palatal canal: It is in between.

6-Maxilla 2nd Molar

-Similar to max. 1“t molar but the distobuccal canal is located in between the mesiobuccal canal and palatal canal and slightly distally. **Average length=20mm**

-Variations: We may have two canals: one buccally and one palatally instead of three canal, in this case the two canals are large in size and opposite to each other.

7-Mandibular1" Molar

-There are three canals, 2 mesially “mesiobuccal and mesiolingual” and one located distally. **Average length=21mm**

-We start preparation in mesial part of the tooth and access opening is triangular, rectangular in shape.

-There is a possibility of 2 canals located distally (33%) “and they may end with separate orifices or joined orifice so if the distal canal is tiny and more toward the buccal side then the possibility of 2 canals is high but if it is in the center buccolingually then the possibility of one canal is high.

8-Mandibular 2nd Molar

-The access opening resembles that of the mand.1“molar with 3 root canals, 2 mesially and 1 distally. **Average length=20mm**

-There is a possibility of 2 canals: mesial canal and distal canal with each canal opposite to other.

NOTE:

Currently, new concepts in endodontic access opening have been developed namely Ninja access opening in order to preserve the amount of tooth structure during root canal treatment procedure. Ninja access opening is one of the important steps towards improving the quality of root canal treatment as well as achieving “a minimally invasive endodontic" concept.

Minimal invasive endodontics: is paramount, even for preparing endodontic access cavity, as removing as little tooth structure as possible allowing us to maintain as much tooth strength as possible. Thus, improving fracture resistance of endodontically treated teeth.

Access Opening Preparation

Guidelines for access cavity preparation:

1) Study the preoperative radiograph: It gives information about the size, shape, number and curvature of the root canals and roots. One should check the depth of preparation by aligning the bur and handpiece against the radiograph.

Preoperative radiograph can help to note the position and depth of pulp chamber

2) Excavate all the carious lesions: No caries should be left in the tooth, because microorganisms of the carious lesion may be introduced inside the canal and infection might occur.

3) Replace any defective filling: The defective filling should be replaced before beginning the access opening because it will not ensure proper seal of the tooth.

4) Remove unsupported tooth structure: Any weak tooth structure might fracture that

causes loss of the seal of the tooth and the reference point which changes the length of the tooth.

Burs used for access cavity preparation

Access openings burs: they are round burs with 16mm bur shank.

Access refining burs: these are coarse flame-shaped, tapered round and diamonds for refining the walls of access cavity preparation

Procedure of Access opening for Anterior Teeth:

1) Entrance is always gained through the lingual surface of all anterior teeth. The initial penetration is prepared in the exact center of the tooth above the cingulum (in the center of the middle third).

2) The initial entry in the enamel is done by a round bur no. 4 operated at a right angle to the palatal surface of the tooth. The guide for enamel penetration is that only the head of the round bur no. 4 should enter the tooth.

The direction of the bur is changed to be parallel to the long axis of the tooth, and drill until the entrance to the pulp chamber. We can know that we reached the pulp chamber when we feel a fall in the resistance to the bur, the bur falls into a space, which is the pulp.

3) Remove the roof of the pulp chamber by working from inside the chamber towards the outside of the chamber (pulling motion).

4) Lingual shoulder is removed by moving the bur from inside towards the outside to give a continuous smooth flaring preparation. Lingual shoulder is a convexity inside the pulp chamber.

5) Finishing and funneling with a fissure bur. The final shape funnels down to the orifice of the canal and flare outwards.

6) Extirpate the pulp by introducing an instrument called the barbed broach in the root canal and by outward movement the barbed broach will catch the pulp and remove it from the root canal.

7) lrrigation of the pulp chamber.

The pulp horns should be eliminated with a round bur no. 2 used laterally and incisally, because if they remain, remnants of necrotic tissue would cause discoloration to the anterior teeth.

<u>Procedure of Access Opening for Premolars:</u>

1) Access is always gained through occlusal surface of all posterior teeth at the center of the central groove. Initial penetration is made parallel to the long axis of the tooth into the exact center of the central groove.

2) A round bur no. 2 or 4 is used to open into the pulp chamber.

3) The bur will be felt to drop it the pulp is reached.

4) We extend into the cavity bucco-lingually by removing the roof of the pulp chamber, working from inside the cavity to the outside (pulling motion).

5) Finishing the cavity walls is done with a fissure bur. The final access opening would be ovoid in shape buccolingually which reflects the anatomy of the pulp chamber and position of the buccal and lingual canal orifices. The pulp chamber of the lower premolars is buccally located rather than lingually so we start access opening and push more buccally.

Access for upper premolars: There are 2 canals, the buccal canal is approached palatally and the palatal canal buccally.

* Floor of the pulp chamber should not be reached.

Anomalies of pulp cavities:

We have certain anomalies which interfere with root canal treatment ex: calcification or complete obliteration of root canal, open apecies, pulp chamber with root canal etc...

1-Dentinogenesls imperfecta: There is a small pulp chamber with root canal obstruction.

2-Hyperparathyroidism: There is a calcafied pulp chamber and loss dura.

3-Hypofunction of pituitary gland: There is a retarded eruption of the teeth and the apecies of the root will be opened.

4-Dentinal dysplasia: There is an obliteration of the pulp chamber and the root formation is defected.

5-Shell teeth: The pulp chamber is quite big with short root.

6-Dense invagination: There is an improper shape of root canal.

Errors in Access Ogening:

1-Perforation: It is common when drilling is continued apically or laterally after we reach the pulp chamber. it is mostly see in

a) Old patients. It is due to pulp recession.

b) Teeth restored by crowns, inlays or big restorations. It is difficult to know the long axis of the tooth so it is better to remove the restoration and work.

d) Tilted teeth. Failure to complete a convenient extension.

2-Cutting more apically: it will lead to flattening of the floor of the pulp chamber and this will weaken the tooth structure which will cause

a) Losing the tunneling shape of the canal orifice.

b) Perforation into the lam.

c) Gauging: Going laterally in the access opening.so the wall of the cavity will not continue with the wall of the root canal.

3-Narrow access opening. This will cause incomplete pulp extirpation and instrumentation through the pulp chamber or pulp horn. This is identified by:

a) Sever bleeding.

b) Change of the color of the floor dentin, to dark blue.

c) Anatomical land marks of the floor of pulp chamber, which are convex floor and presence of grooves connecting the canal orifices, are not seen clearly.

d) If a probe is placed in the pulp chamber and pulled against the walls and it catches in the pulp chamber then there is still roof of the pulp chamber, therefore indicating presence of remnants of pulp tissue.

4) Entrance through labial surface. This is sometimes performed due to severe crowding or caries in labial surface. or proximal surface if the adjacent tooth is missing. This type of access opening causes incomplete pulp extirpation.

5) Extended access opening preparation: This access opening causes undermining and weakening of the enamel walls.

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Endodontic Instruments:

There are many instruments used in the different phases of endodontic treatment and they are as follows:

- ### General Instruments

1) Endodontic Explores: A double end instrument. one end is straight used to locate the root canal princes IROI' the removal of the pup chamber and the other end is L-shaped which aids in down" the unmoved part of the tooth as the roof of pulp chamber

2) Plastic Instruments: It has two ends; the first is used to carry cement and base material. The opposite end is used as a plugger to condense the materials in the root canal.

3) Endodontic Excavator: It is larger than a spoon excavator,also used in curettage and excavation of the contents of the pulp chamber and periapical lesions in surgical endodontics (apicectomy).

4) Endodontic Locking Pliers (tweezer): It has a lock that allows materials to be held without continuous finger pressure; also, it has a groove which facilitates holding gutta percha and absorbing points.

5) Endodontic Ruler: It is a metal ruler made of 0.5mm divisions. It is a convenient instrument to measure reamers, files and gutta percha.

6) Endodontic Syringe: It is used to carry irrigating solution into the root canal. The tip of the instrument is flat to prevent penetration of the needle to the small canals; also it has a groove in its tip to permit the irrigation which might be

under pressure to flow coronally rather than forcing it to the apical foramen causing post-operative pain.

7) Instrument Organizer (endodontic kit): It is used for arrangement of reamers and files according to the size and length. The organizer provides holes for the files to be place vertically in a sponge which is saturated with disinfectant to maintain its sterility.

8) Transfer Sponge: it is sponge saturated with disinfectant solution, The reamers and files can be placed in it after being used.

9) Instrument Stopper (rubber stopper): It is used to mark the length of the tooth on reamers and files; it should be perpendicular to the long axis of the reamer. It may be made of rubber or metal.

▪ Intracanal Instruments:

ISO Grouping of Instruments

In due time, the ISO committee grouped intracanal root canal instruments according to their method of use:

Group I	**Hand use only—files,** both **K** type (Kerr) and **H** (Hedstroem); **reamers, K** type and **U** type; and broaches, pluggers, and spreaders.
Group II	**Engine-driven** latch type—same design as Group I but made to be attached to a handpiece. Also included are paste fillers.
Group III	**Engine-driven** latch type—**drills** or reamers such as Gates-Glidden (**G** type). Peeso (**P** type), and a host of others.
Group IV	**Root canal points—**gutta-percha, silver, paper.

Group I:

These instruments are used inside the root canal

1) Barbed broach:

This instrument is used inside the canal. It is a short-handled instrument with a shaft having projections directed obliquely towards the handle. It is made of stainless steel, and used for pulp (vital pulp) extirpation, and removal of necrotic tooth debris inside the canal. It can be used to remove cotton and paper points from the canal. It is used in straight parts of the canal and inserted freely (by using the suitable size) to the 2/3 of the pulp canal; otherwise, fracture of the instrument may occur.

2) K-Reamers and K-files:

These instruments are made of stainless steel, because it is more flexible than carbon steel and don't corrode, but nowadays, a super flexible material which is Nickie-Titanium is used. Reamers and files are manufactured by twisting a square bar to produce flutes but they differ in the number of flutes.

a) Reamers are mostly used in reaming action and are less effective in filing action. Reamer = 0.5-1 flute/mm.

b) Files are less flexible than reamers. It is mostly used in filing action but can be used in reaming action. K file = 1.5-2.25 flute/mm

c) K flex file: It is a diamond cross section bar. it is more fixable and sharper blades with non-cutting tip (blind tip).

d) Hedstorm files: They are machined instrument that are made of stainless steel bar which are triangular in shape with very sharp edges.They are very active in just pulling action while K files are effective in both pulling and pushing action. **It cannot be used in rotation movement.**

- ## Differences between reamers and files

	Reamer	File
1	More flexible	Less flexible.
2	Less no. of cutting flutes	More no. of cutting flutes
3	Used mainly in reaming action	Used mainly in filing action
4	Less effective in filing action because less no. of flutes	Rotation Can be used in reaming action
5	cutting motion is rotation and retraction	Push Pull
6	Cross section is Triangular	Square
7	Round preparation shape	Ovoid

Note: Triangular cross-sectioned files show superior cutting and increased flexibility than the file or reamers with square blank

3) Spreader:

It is a long, tapered and pointed end Instrument, which is used to compress gutta percha into the apex and periphery of the prepared canal and also towards the irregularity of canals leaving a space for insertion of auxiliary root canal filling material cones. There is also a finger spread and long handled which is smaller and shorter to be used in posterior teeth.

4) Plugger

It is a long and blunt flat tip blade instrument which is necessary for vertical condensation technique and also plugging of gutta-percha at the termination of all other obturation condensation techniques. There are 2 types of pluggers, the long-handled type and finger type.

- ## Standardization of Intracanal Instruments:

Each instrument has a number which refers to the size of its tip. The reamer of size 30 means that Do = 0.3mm, while size 70 reamer means that D0 = 0.7mm.

$$\mathbf{Dx = D_0 + (x * tapering)}$$

Example D8 for file size 10 iso (taper 0.02)

D8= 10+(8*0.02) =10+16 =26	**D16 = 10+ 0.32 mm** =42

So, in size 50 reamer, the tip (Do) is 0.5 mm while D16 is 0.82 mm. The distance between Do and D16 is 16mm, but the total length differs from short to medium to long for anterior teeth and the shorter ones for posterior teeth.

All intracanal instruments are color coded and each color represents a size. Pink= 6. Gray= 8, Purple= 10. White: 15, Yellow3 20, Red= 25. Blue= 30. Green=35, Black= 40, then the colour returns to White= increase by 10 as Green=70, Black=80, and so onto size 140.

- ## Modes of action of lntracanal Instruments:

1) Reaming action: It is a repeated clockwise rotation of the instrument which will shave the canal walls and give a cross sectional preparation approximately round. Reamers are usually more effective for this function.

2) Filing action: It is a push-pull action without rotation which has a great efficiency with files than reamers. The cross-sectional appearance of the prepared root canal is irregular with general oval configuration, so the canal must be filled with gutta percha.

3) Quarter-tum filing: This action is a combination of reaming and filing action. The instrument is inserted in the root with a quarter turn rotation (90°) then moved with dragging motion to produce an oval cross section. K-file and reamer can be used.

4) Circumferential filing: in this action. filing or quarter turn filing action is used with emphasis placed on the out stroke, so the file is dragged along different sides of the canal wall with each withdrawal. The resultant canal has a wide orifice with greater taper.

ENDODONTICS

Lecture 5 Asst Lect. Othman H.Alani

Nickel – Titanium endodontic Instrument

A new generation of an endodontic instrument made from remarkable alloy, Nickel – titanium has added a striking new dimension to the practice of endodontic. The super elasticity of Ni-Ti differentiate it from other metals such as stainless steel that sustain deformation and retain permanent change shape. These properties make nickel-titanium endodontic files more flexible and better able to conform to canal curvature, resist fracture, and wear less than stainless steel files.

Advantages

1- NiTi files are more flexible than the stainless-steel files (low modulus of elasticity).
2- Superior resistance to fracture in a clockwise or counter-clockwise reaming motion.
3- They are biocompatible and appear to have excellent anticorrosive properties.
4- These instruments maintain the original shape of the curved canal and remain centered in the canal and cause the least amount of apical transportation, zipping, elbow, and ledging.
5- They have good resistance to untwisting, rounding of edges and tip alternation.
6- They are significantly faster than other instruments.
7- Concerning cutting efficiency as well as instrumentation of curved canals Ni-Ti instrument were clearly superior to all another instrument.

Disadvantages

1- Their high expense.
2- The penetration ability of Ni-Ti instruments seems to be less than that of stainless-steel instruments.
3- Ni-Ti instruments have an inability to bypass or remove ledge.
4- These instruments break without any previous sign of their fracture such as untwisting of the file, unlike stainless steel instruments which allow discarding the instrument before fracture.

ISO Group II and III: Engine – driven instruments can be used in three types of contra angle handpieces:

1- Rotary contra angle handpiece: The instrumentation with a full rotary handpiece is by straight line drilling full rotary contra angles are used primarily to develop coronal access to the canal orifices. In addition, special drills or reamers, listed under ISO Group II, may be used to funnel out orifices for easier access, to widen as much 2/3 of the canal, or to prepare post canals for final restriction of the tooth.

Since most of these instruments do not bend, they should primarily be used in straight canals because they are often misdirected or forced beyond their limits. They will cause perforations or break in the hands of the instruments. Lack of tactile sense is a real problem, and the slower handpiece improves this.

An entirely new 'wrinkle' in rotary handpieces is the **Morita Tri Auto – ZX**, a cordless, battery – powered, endodontic slow speed (280 rpm) handpiece with a built – in apex locator.

It uses rotary nickel-titanium instruments held by a push button chuck. The Tri **Auto – ZX** has three automatic functions. The handpiece automatically starts when the file enters the canal and stops when the file is removed, if too much pressure is applied, the handpiece automatically stops and reverse rotation. It also automatically stops and reverses rotation when the file tip reaches the apical stop, as determined by the built in apex locator. The Tri Auto ZX will work in a moist canal.

2- Reciprocating Handpiece: To overcome the inflexibility of conventional endodontic hand instrument, the Giromatic (quart turn endodontic handpiece) was introduced in 1964. This handpiece operates by rotary-reciprocal action through a 90 – degree, which delivered 3000 times per minutes.

Rotary instruments:

1-Gates-Glidden drills.
2-Pesso reamers.
3- Engine – driven files

1- Gates – Glidden drills: These are an integral part of new instrument techniques which have many uses:

1. To open the canal orifice.
2. To achieve straight line access by removing the dentin shelf.
3. To flare the coronal and middle third of the canal rapidly

The Gates-Glidden drills are steel instruments for the contra-angled handpiece characterized by a long shank and an elliptical extremity which is flame shaped with a "guiding" non-cutting tip The Gates-Glidden drills

are available in six sizes and marked with circular notches on the part that attaches to the contra-angled handpiece; The Gates-Glidden drills are designed with the weakest point at the start of the shank, so that they are easier to remove in case they fracture inside the root canal The Gates drills must be used passively on withdrawal from the canal with a brush like circumferential movement and their use must always be preceded by preflaring of the canal using hand instruments. An active use of the Gates Glidden drills is not recommended because they can lead to the formation of ledges and dangerous structural weakening that in the curved and thin canals can cause stripping. The blades of the Gates-Glidden drills do not have angles but flat cutting planes to reduce the aggressiveness and the tendency to screw in; they could be considered as the first example of the "radial lands" type of blades.
Used at slow speed for preparing the coronal 2/3 of the canal. It is used in withdraw the motion to remove tooth structure. They come in the following sizes:
Number 1 equal to ISO 50
Number 2 equal to ISO 70
Number 3 equal to ISO 90
Number 4 equal to ISO 110
Number 5 equal to ISO 130
Number 6 equal to ISO 150

2- Pesso reamers:
Peeso Reamers are steel instruments for the contra-angled handpiece similar to the Gates-Glidden drills, from which they differ in that the blades are spread over a wider surface and the shape that is cylindrical. The design of the blade (radial lands type) and the non-cutting tip is, in fact, identical to that of the Gates drills. On the contrary, the Peeso drills are very useful in the preparation of the dowel space (post space) in canals already enlarged or in retreatments to speed up the removal of the obturation material.

These instruments are available with or without safe tips. Gutta-percha should have previously been removed to post depth with a hot plugger. Pesso resembles The Gates-Glidden drills in sizes.

3- Engine – driven files:
<u>ProTapers</u>

The ProTaper System is made up of 6 instruments that are divided into 2 groups of 3 instruments each: Shapers with the marking SX, S1 and S2 and Finishers with the marking F1, F2, and F3. The Shapers are instruments for eliminating coronal interferences and to create a smooth pathway for the Finishing instruments while the Finishers are meant for the finalizing of the shape created by the Shapers and for giving a definitive taper and diameter to the canal. The S-X Shaper is an auxiliary instrument used in canals of teeth with shorter roots or to extend and expand the coronal aspects of the preparation, similar to the use of Gates-Glidden drills or orifice openers. Sx has a much quicker rate of taper between D1 and D9 as compared with the other ProTaper Shaping files. Shaping File S-1 is designed to prepare the coronal 1/3 of the canal, whereas Shaping File S-2 enlarges and prepares the middle third in addition to the critical coronal region of the apical third. The important structural characteristics of the ProTapers are

– Robust triangular cross-section with convex sides to increase the metal mass of the central core resistance of the instruments;
– cutting blades with cutting angles (there are no radial lands);
– Variable helical angle to reduce screw in risk;
– Variable pitch (distance between spirals) to reduce the risk of screw in and aid the removal of debris;
– Multiple increases in tapers towards the handle of the shapers (so as to increase the flexibility in the apical third) and decrease towards the handle in the Finishers (so as to enlarge the apical preparation without making the coronal third of the instrument too rigid).

The WaveOneTM single file reciprocating system

The new WaveOneTM NiTi file from DENTSPLY Maillefer is a single use, a single file system designed to completely shape the root canal from start to finish.

Path Files

Mechanical glide path and Preflaring.

Available in 3 ISO sizes (013, 016 and 019) and 3 lengths (21, 25 and 31mm). Flexible and resistant to cyclic fatigue, they offer many advantages compared to manual solutions

Pathfinder: These are used for negotiation of irregular calcified canal when it is difficult to use 06, 08 and 10 files which may prove to tip fracture, so that to avoid this problem pathfinder files can be used, these files are available in two sizes K1 (between 06 and 08) and K2 (between 08 and 10). They are made of stainless steel or carbon steel (become more rigid).

The taper of their instruments reduced to give the tip a greater rigidity so that more apical pressure can be applied without the risk of tip bending damage to the tip of the small instrument may be due to a relatively abrupt change in the direction of the canal.

- **Ultrasonic Handpieces:** Instruments used in the hand pieces that move near or faster than the speed of sound range from standard K – type files to special broach like instruments.

Ultrasonic endodontic is based on a system in which sound as an energy source activates an endodontic file resulting in three-dimensional activation of the file in the surrounding medium.

The main debriding action of ultrasonic was initially thought to be by cavitation, a process by which bubbles formed from the action of the file, become unstable, collapse and cause a vacuum like ‘explosion’. A combined shock, shear and vacuum action results. Since an irrigation and aspiration system is employed in the endodontic equipment for ultrasonic, the broken cell parts are washed out and then removed from the canal system.

The cleaning efficacy can be enhanced by placing an ultrasonic tip into the irrigated space of the canal. Ultrasonic creates both cavitation and acoustic streaming. The cavitation created is minimal and is restricted to the tip. However, the acoustic streaming effect is significant. These motions allow cleaning and flushing out of areas that files may not be able to negotiate.

- **Sonic handpieces:** The endo MM 1500 (Endo Micro – Mega 1500) was developed as sonic vibratory handpiece (special handpiece) to be attached to the turbine line of a dental unit. The handpiece operates at a frequency of 1500 HZ at a pressure 0.4 Mpa tap water irrigant and coolant is delivered into the preparation from the handpiece.

These instruments have safe ended non cutting tips. 1.5 – 2 mm in length. Those files were particularly ineffective in widening the canal as the previous two instruments. The root canal instrument vibrates in the simpler pattern than ultrasonic files. A continuous flow of water is delivered through the handpiece to the instrument.

Lecture 6 د. عثمان هشام العاني

Rubber Dam

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 RD. 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 RB. clamps, and each one of them is placed in a different tooth or region.

Rubber Dam Puncture

It is an 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.

Clamp Holder

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

Methods of Applying The Rubber Dam

- **Method 1:** Application of the clam & rubber dam together

-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.

-Re-stretch 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.

Advantages

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.

Disadvantage

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

❖ **Method 2** : Application of clam& then dam.

-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-t 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 clam

-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 is 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.

ENDODONTICS

Lecture 7 د. عثمان هشام العاني

Radiography in Endodontics

There are many applications of radiographs in endodontics including:

1) Aid in the diagnosis and localization of hard tissue alteration of the tooth (sclerosis and resorption) and periradicular structures.

2) Determine the number, location, size, shape and direction of roots and root canals.

3) Estimate and confirm the length of root canals prior to instrumentation.

4) Determine the relative position of structures in facial or lingual dimensions.

5) Confirm the position and adaptation of the filling points.

6) Assess the outcome of root canal treatment

Working Length determination of teeth:

Determination of an accurate working length is one of the most critical steps of endodontic therapy. The cleaning, shaping and obturation of the root canal system cannot be accomplished accurately unless working length is determined precisely. According to endodontic glossary, working length is defined as "the distance from a coronal reference point to a point at which canal preparation and obturation should terminate".

Objective of the working length

To establish the length of the tooth at which the canal preparation and subsequent obturation are to be completed. The apical end of the root canal is the CDJ, which is usually 0.5-1mm short of the radiographic apex. Sometimes the apical foramen is laterally positioned so it would be more than 1 mm from the radiographic apex.
Reference point: It is the site on the incisal edge or occlusal surface from which measurements are made. Usually it's the highest point on the incisal edge in anterior teeth & the tip of the cusp in posterior teeth.

It should be:

1) Stable

2) Easily visualized during preparation

3) not changing during or between appointment

Before we discuss various methods of detennination of working length, we need to understand the anatomic consideration regarding it.

1. Anatomic apex: is "tip or end of root determined morphologically".

2. Radiographic apex: is "tip or end of root determined radiographically".

3. Apical foramen: is main apical opening of the root canal which may be located away Eom anatomic or radiographic apex.

4. Apical constriction (minor apical diameter): is apical portion of root canal having narrowest diameter. It is usually 0.5 -1 mm short of apical foramen. The minor diameter widens apically to foramen, i.e. major diameter.

5. Cementodentinal junction: is the region where cementum and dentin are united, the point at which cemental surface terminates at or near the apex of tooth. It is not always necessal, that CDJ always coincide with apical constriction. Location of CDJ ranges from 0.5-3 mm short of anatomic apex

Consequences of over-extended working length

- Perforation through apical construction
- Over instrumentation
- Overfilling of root canal
- Increased incidence of postoperative pain
- Prolonged healing period
- Lower success rate due to incomplete regeneration of cementum, periodontal ligament and alveolar bone.

Consequences of working short of actual working length

- Incomplete cleaning and instrumentation of the canal
- Persistent discomfort due to presence of pulpal remnants
- Underflllling of the root canal
- Incomplete apical seal
- Apical leakage which supports existence of viable bacteria, this further leads to poor healing and periradicular lesion.

DIFFERENT METHODS OF WORKING LENGTH DETERMINATION

Various methods for determining working length include using average root lengths from anatomic studies, preoperative radiographs, tactile sensation, etc. Other common methods include use of paper point, working length radiograph, electronic apex locators or any combination of the above.

1. RADIOGRAPHIC METHOD OF WORKING LENGTH DETERMINATION

Procedure of Working Length determination

1-Examine preoperative radiograph & estimate the length of the tooth.

2-Know the average length of each tooth.

3-Place the file selected to be the correct initial width into the canal with it's rubber stopper set at the estimated working length.

4-Radiograph the tooth to verify the position of the instrument.

5-Readjust the file length according to the radiograph result.

Results are either fit, too long, or too short.

Notes: * Bisecting technique in x-ray can't measure the exact length of the tooth. The parallel technique is more accurate

*The radiographs should be repeated in the following stages of treatment to check the working length.

* Initial size: It is the first instrument used to fit the working length & has slight resistance.

* If the radiograph results are too long e.g. 3mm. long, here we have to subtract 4 mm. & take another radiograph.

"' If the radiograph results are too short e.g. 3mm. short, here we have to add 2mm. & then take another radiograph.

When two superimposed canals are present (for example buccal and palatal canals of maxillary premolar, mesial canals of mandibular molar)

One should take following steps:

a. Take two individual radiographs with instrument placed in each canal.

b. Take radiograph at different angulations, usually 20° to 40° at horizontal angulation.

c. Insert two different instrument, e.g. K file in one canal, H file/ reamer in other canal and take radiograph at different angulations.

d. Apply SLOB rule, that is expose tooth from mesial or distal horizontal angle, canal which moves to Same direction, is Lingual whereas canal which moves to Opposite direction is Buccal.

2. ELECTRONIC APEX LOCATORS

Radiographs are often misinterpreted because of difficulty in distinguishing the radicular anatomy and pathosis from normal structures. Electronic apex locators (EAL) are used for determining working length as an adjunct to radiography. They are basically used to locate the apical constriction or cementodentinal junction or the apical foramen, and not the radiographic apex.

ENDODONTICS

<u>Lecture 8</u> Asst Lect. Othman H.Alani

Shaping and Cleaning of Root Canal

The major biologic aim of endodontic therapy is to eliminate apical periodontitis by disinfection and sealing of root canal systems. Although "cleaning and shaping" accurately describes the mechanical procedures, it should be emphasized that enlarging canals directly facilitate the cleaning action of irrigants and the removal of infected dentin. Therefore, the objectives of root canal treatment could be divided into Mechanical and Biological. Schilder described 5 mechanical and 4 biological objectives for successful root canal therapy. **The Mechanical objectives are:**

1. The root canal preparation should develop a continuously tapering cone. This shape mimics the natural canal shape.

2. Making the preparation in multiple planes. This objective preserves the natural curve of the canal.

3. Making the canal narrower apically and widest coronally. To create a continuous taper up to apical third which creates the resistance form to hold gutta-percha in the canal.

4. Avoid transportation of the foramen. There should be gentle enlargement of the foramen while maintaining its position.

5. Keep the apical foramen as small as possible. Since over-enlargement of the apical opening contributes to number of iatrogenic problems. Doubling the file size apically increases the surface area of foramen for four folds.

The Biological objectives are:

1.Confinement of instrumentation within the root canals only.

2.Ensure not to force necrotic or instrumentation debris beyond the apical foramen.

3.Optimum debridement of the root canal space.

4.Creation of sufficient space for intra-canal medicaments.

Aids in Preparation of Root Canal

1.A Patency File (glide-path file): is a small K-file (usually a size #10 or #15) that is passively extended just through the apical foramen. This ensures opening of the canals and facilitate working length estimation.

2.Precurved instrument: In case of a curved canal, the instrument should be precurved to estimate the curvature of the canal. This is true only in case of stainless-steel instrument, but nickel titanium instrument is flexible and cannot be curved.

3.The use of intracanal irrigation solutions that serve many advantages such as dissolving and flushing out of the debris from the root canal, lubricant for the cutting motion of the files within the canal, in addition to its antimicrobial activities. The most popular intra-canal irrigation solution is Sodium hypochlorite (NaOCI) 2.5-5.25%. This can be delivered inside the canal by using hypodermic syringe. (More details about irrigation and irriggant solutions will be discussed in the next lecture)

4.Examination of the instruments: Each instrument should be examined each time before insertion inside the root canal to verify the presence of any sign of fatigue, stress or damage. so, any instrument showing such a sign should be discarded.

5.Use of instruments in sequential order: Root canal preparation is done gradually by using successively larger files (never skip any size of instrument) e.g. size 20 followed by size 25 then 30 and so on, but not size 20 then size 30.

Manual or Hand Instrumentation Techniques:

Several methods were developed for manual root canal preparation:

1-Standardized Technique:

This technique is developed by Ingle and uses the same working length (WL) definition for all instruments introduced into a root canal. Therefore, relies on the inherent shape of the instruments to impart the final shape of the canal. It is also called **‘single-length technique’**.

In the beginning the canal is irrigated, then negotiation of fine canals is initiated with lubricated fine files in a so-called watch-winding movement until reaching to full WL. In watch winding motion, a gentle clockwise and anticlockwise rotation of file with minimal apical pressure is given.

Canal preparation then continues with reaming or quarter-turn-and-pull motions until a next large instrument reached.

This technique will produce a canal shape or taper that resembles the tapering of the final instrument which is called the master apical file (MAF).

Creation of a true standardized tapered preparation is difficult in ideal straight canals and impossible in curved canals.

A single match gutta percha point may then be used for root canal filling with inadequate space to do lateral compaction of gutta percha in such small canal tapering (0.02).

Disadvantages of Standardized technique:

1-Chances of loss of working length due to accumulation of dentin debris.

2-Increased incidences of ledging, zipping and perforation in curved canals.

2-Step-Back Technique:

Realizing the importance of a canal shape larger than that produced with the standardized approach, the step-back technique was introduced by Clem and Weine in 1960. This technique relies on stepwise reduction of WL for larger files, typically in 1or 0.5-mm steps, resulting in flared shapes with 0.05 and 0.10 taper, respectively. The final result is a preparation with small apical enlargement and marked taper from apical to coronal. The wide, less flexible instruments are avoided in the preparation of the apical portion of the canal. This will lessened the forces by these instruments on the canal walls, which in turn preserve the original shape of the canal. Filling with gutta percha is made easier because more room space will be available for spreader & plugger to penetrate more apically to get maximum condensation. The technique is as follow:

- After access of the pulp chamber and opening of the canal orifices, flood the pulp chamber with irrigant.
- Establish the working length of each canal using path file which could be file # 10 .
- Insert the next size file (# 15) into the full WL of the canal with a gentle watch winding motion . Then start acting the file on the canal walls either with filing or quarter-turn-and-pull motion until the file becomes loosely moved within the canal.
- Remove the instrument and irrigate the canal.
- Place the next larger size files to the working length in similar manner and again irrigate the canal, until a clean white dentin will appear on the file tip. This file is called the MAF which is the final instrument that goes to the full working length.
- Don't forget to recapitulate the canal with the previous smaller size instrument. This breaks up apical debris to be easily washed away with the irrigant.
- Next use a larger file, i.e. one size larger than MAF into 0.5 to1 mm shorter than WL . Then recapitulate the canal with MAF to full WL of the canal with irrigation to remove apical debris and maintain the WL.

This process can be repeated to 3 or more, larger files until a good flaring and cleaning of the canal is obtained Furthermore, flaring of the coronal third of the canal can be more enlarged by using Gates Glidden rotary drills to obtain better canal cleaning coronally.

Advantages of step-back technique:

More flare at coronal part of root canal with proper apical stop.

Disadvantages of step-back technique:

1. Difficult to irrigate. apical region.

2. More chances of pushing debris periapically.

3. Time consuming.

4. Increased chances of iatrogenic errors for example ledge formation in curved canals.

5. Difficult to penetrate instruments in the canal.

6. More chances of instrument fracture.

3-Step-Down Technique:

This technique was developed to shape the coronal part (coronal preflaring) of the canal before instrumentation of the apical part. The objectives of this technique are:

1-To permit straight access to the apical region of the canal by eliminating coronal interference.

2-To remove the bulk of necrotic tissue and microorganisms before apical shaping to minimize extruded debris through the apical foramen during instrumentation.

3-To allow deeper penetration of irrigant deeply into the apical part of the canal. In addition, it provides coronal escape way for debris extrusion from the apex.

4-The WL is less likely to change with less chance of zipping near the apical constriction.

Procedure:

- Preparation of two coronal root canal thirds using Hedstrom files of size #15, #20, and #25 to 16 - 18 mm or where they bind. These files are used with circumferential filing motion on the canal walls.

- Thereafter, increasing the coronal flaring of the canal by using Gates-Glidden drills size 2. 3, and 4, in sequential order and 1mm shorter length between each file.

- Followed by canal WL estimation, then instrumentation of the remaining apical part of the canal. This includes using small K-file # 15, 20 and 25 to prepare the apical seat.

- Combining the two parts. step-down and apical shape, by stepwise decreasing of WL of incrementally larger files. Frequent recapitulation with a #25 K-file to WL is advised to prevent blockage.

4-Balanced Force Technique:

This technique was introduced by Roane and Sabala in 1985, after the development of new file 'FIex-R file'. This file has "safe tip design" with a guiding land area behind the tip which allows the file to follow the canal curvature without binding in the outside wall of the curved canal. While the old K-type files have pyramidal tips with cutting angles which can be quite aggressive with clockwise rotation. This technique can be described as positioning and preloading an instrument through a clockwise rotation and then shaping the canal with a counterclockwise rotation.

Procedure:

1.In balanced force technique, preparation is completed in a step-down approach. The coronal and mid-thirds of a canal are flared with GG drills, beginning with small sizes as described previously.

2.After that, the balanced force hand instrumentation begins in the apical preparation by placing. cutting, and removing instrument using only rotation motion. First file which binds short of working length is inserted into the canal and rotated clockwise a quarter of a turn. This movement causes flutes to engage a small amount of dentin.

3. Now file is rotated counterclockwise with apical pressure at least one third of a revolution. It is the counterclockwise rotation with apical pressure which actually provides the cutting action by shearing off small amount of dentin engaged during clockwise rotation.

4. Then a final clockwise rotation is given to the instrument which loads the flutes of file with loosened debris and the file is withdrawn.

5. Balanced Force instrumentation initiated from the belief that the apical area should be shaped to sizes larger than were generally practiced. The original Balanced Force concept then refers to apical control zones by, for example, first using sizes #15 and #20 files to the periodontal ligament (i.e., through the apical foramen) and then reducing the working depth by 0.5 mm for subsequent sizes #25, #30, and #35. The apical shape is then completed 1 mm short using sizes #40 and #45 under continuing irrigation with NaOCl.

Advantages of balanced force technique

Lesser chances of creating a ledge, blockage or canal transportation.

5-Crown-Down (Pressure-Less) Technique:

The crown-down instrumentation concept based on the canal shaping technique moving from the crown toward the apical portion of the canal. This concept was the introductory for the most recent rotary instrumentation technology.

Procedure:

1. After preparing the access opening and locating the canal, flood the pulp chamber with irrigation solution and start preflaring of the canal orifices. This can be done by using hand instruments, Gates-Glidden drills or the Nickle-Titanium rotary instruments. After that a glide-path for each canal have to be obtained from the canal orifice till the apical foramen by using # 10 or 15 file.

2. Coronal preparation of the canal can be started with Gates-Glidden drills. The crown down approach begins with larger Gates-Glidden first (size 4 or 5). followed

by smaller diameter Gates-Glidden are worked into the canal with additional mm to complete coronal flaring. A care should be taken to avoid carrying all the Gates-Glidden drills to same level which may lead to excessive cutting of the dentin.

3. Frequent irrigation with sodium hypochlorite and recapitulation with a smaller file (usually No. 10 file) to prevent canal blockage.

4. After establishing coronal and mid root enlargement, establish the working length with small instruments (# 10 or 15 file).

5. Introduce larger files to coronal part of the canal and prepare It . Subsequently introduce progressively smaller number files deeper into the canal in sequential order and prepare the apical part of the canal .

6. Final apical preparation is prepared and finished along with frequent irrigation of the canal system.

Biological Advantages of crown down technique:

1. Removal of tissue debris coronally, periapically. thus, minimizing the extrusion of debris.

2. Reduction of postoperative sensitivity which could result from periapical extrusion of debris.

3. Greater volumes of irrigants can reach in canal irregularities in early stages of canal preparation because of coronal flaring.

4. Better dissolution of tissue with increased penetration of the irrigants.

Clinical advantages of crown down technique:

1. Enhanced tactile sensation with instruments because of removal of coronal interferences.

2. Flexible (smaller) files are used in apical portion of the canal; whereas larger (stiffer) files need not be forced but kept short of the apex. This decreases the chance for canal ledging, transportation and perforation.

3. Straight line access to root curves and canal junctions.

4. Provides more space for irrigants.

5. Enhance canal debridement and decrease frequency of canal blockages.

6. Desired shape of canal can be obtained that is narrow apically and wider coronally.

This provides better room for Gutta Percha condensation to obtain proper three dimensional obturation of the root canal.

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ENDODONTICS

<u>Lecture :9</u> Asst Lect. Othman H.Alani

Root Canal Irrigation

- Studies have shown that mechanical instrumentation, whether using manual or rotary instruments, can not sufficiently debride and disinfect root canals. Every root canal system has spaces that cannot be cleaned mechanically.
- ‘The only way for cleaning webs, fins and anastomoses is through the effective using of irrigation solutions .

Requirements of ideal irrigant solution:

1.Have a broad-spectrum antimicrobial activity.

2.Be able to effectively sterile the canal (or at least disinfect them).

3.Have the ability to dissolve necrotic tissue and debride the canal.

4.Lubricant solution.

5.Low level of toxicity.

6.Have low surface tension to be able to penetrate into inaccessible areas.

7.Prevent the formation of smear layer during or after instrumentation. 8Inhibiting bacterial toxins such as endotoxin.

Functions of lrrlgants

1.Removal of dentinal shavings by physical flushing to prevent their packing at the apical region of the root canal.

2.Canal wetting material which effectively Increase the efficacy of root canal instruments. Instruments are less likely to break when the canal walls are lubricated by irrigant.

3.lrrigants act as a solvent for necrotic tissue, so they loosen debris, pulp tissue and microorganisms from irregular dentinal walls.

4.lrrigants facilitate the removal of debris from inaccessible regions of root canals.
5.Most irrigants have germicidal and antibacterial properties.

6.lrrigants also have bleaching action to lighten teeth discolored by necrotic pulp tissue, caries or restorative material.

7.lrrigats facilitate the removal of smear layer and opening of the dentinal tubules.

Factors that modifying the activity of irrigating solution There are several factors that can be controlled to increase the efticacy of irrigant solutions:

1.Concentration: the dissolving capacity of some irrigation solution, such as sodium hypochlorite, can be increased with higher concentration (5.2 rather than 2.5%). However the cytotoxicity of higher concentrations is extremely higher.

2.Contact: the irrigant must contact the intracanal substrate (organic tissue or microbes) to be effective, otherwise it won't be able to dissolve or flushout the debris. Therefore, it is critical that the canal diameter should be mechanically enlarged to facilitate the delivery of the irrigant solution up to the apical region of the prepared canal.

3.Presence of organic tissue: the organic tissue must be removed mechanicalty or chemomechanically to increase the efficacy of intracanat irrigation. This can be obtained by simultaneous use of instruments and irrigating solutions.

4.Quantity and frequency of the irrigant used:

- More irrigation causes better tissue debrldement.
- Each time a flush of fresh potent lrrigant plays an action.

5.Gauge of irrigating needle: usually the 27 or 28 irrigation needle is preferable for better penetration into the canal.

6.Surface tension of irrigation solution: the lower surface tension, the better

wettability and the more penetration into narrowest areas of the canals, and even into the dentinal tubules.

7.Level of penetration of the irrigant: Maximum actions of irrigant occurs on coronal part of root canal whereas minimal on apical end.

8.Age of irrigant: Freshly prepared solution is more effective than older one.

Irrigant solutions:

There are several irrigation solution that are currently used in root canal chemomechanical debridement nowadays (See Figure 2). But none of these irrigats fulfIl all the required criteria. The main irrigants include sodium hypochlorite,

chlorhexidine and ethylene diamine tetraacetic acid. A combination of several irrigants can be used to get maximum action.

Normal saline:

Normal saline as 0.9% WN is commonly used irrigant in endodontics. it is very mild in action and can be used in adjunct to chemical irrigant. It causes gross debridement and lubrication of the root canal. Normal saline basically acts in flushing action. It can also be used as a fInal rinse for root canals to remove the chemical irrigant left after root canal preparation.

Advantages: it is a biocompatible solution with no adverse effect even if extruded periapically, because its osmotic pressure is the same as that of the blood. Disadvantages:

- It has no dissolution, disinfectant and antimicrobial properties.
- Too mild to thoroughly clean the canal.
- Does not remove sear layer.

Sodium hypochlorite (NaOCI):

NaOCI encompasses many desirable properties of the main root canal irrigant and has therefore been described‘as the most ideal irrigant solution. It can be used with different concentrations (0.5 to 6%) but the recommended concentration in many studies is 5.25%. Commercially avaiiabie household bleach (Clorox) contains 6.15% NaOCI.

NaOCI dissolve organic material such as pulp tissue, collagen, organic material in smear layer and bacteria. With lower concentrations (0.5%) it dissolve only necrotic tissue, however in higher concentrations dissolve both necrotic and vital which is not always a desirable property.

NaOCI possess a broad-spectrum antimicrobial activity against endodontic microorganisms and biofilms, including microbiota difficult to eradicate from root canals, such as Enterococcus, Actinomyces, and Candida organisms. This depends on its concentration and the contact time. With higher concentration and longer contact time its antimicrobial action increase.

NaOCI minimally remove dentin debris or smear layer. Therefore, the use dentin demineralizing agent (EDTA) is recommended post instrumentation to eliminate smear layer and enhance cleaning of difficult-to-reach areas such as dentinal tubules and lateral canals.

When using NaOCI over extended periods of time during treatment, it has an undesired side effect by decreasing the flexural strength and modulus of elasticity of dentin. Therefore it has to be flushed out by using normal saline after the end of instrumentation visit. NaOCI also has bleaching action by the function of the hypochlorite ions which is important in whitening the discolouration caused by pulp necrosis or endodontic and restorative material such as some endodontic sealers and amalgam restoration. However. NaOCI cause bleaching in contact with clothes, so cautions have to be taken during its use.

Although NaOCI is nontoxic during intracanal use, it could cause serious tissue damage if it injected periapically especially with higher concentration This is associated with severepain, swelling and periapical bleeding. Medication like antibiotics, analgesics, antihistamine should be prescribed accordingly. In addition to these. reassurance to the patient is the prime consideration. Thus irrigation with NaOCI should always be performed passively especially in cases with larger apical diameters and needles with very small diameter.

Advantages of NaOCI:

1 it has antibacterial and bleaching action.

2- It help in canal debridement by dissolution of the organic debris

3- lt cause lubrication of canals

4- Economical.

5 Easily available.

Disadvantages:

1-Because of high surface tension, its ability to wet dentin is less.

2-lrritant to tissues, if extruded periapically, it can result in severe cellular damage.

3-it comes in contact, it cause inflammation of gingiva because of its caustic nature.

4-It causes clothes bleaching in contact.

5-It has bad odor and taste

6-Vapours of NaOCI can irritate the eyes.

7-it has a corrosive effect to instruments.

Chelating agent:

After root canal instrumentation, a layer of cutting remnants will cover the dentinal tubules which contain both organic and inorganic materials. This layer is called the smear layer . A big controversy still exist whether to remove or maintain the smear layer which may affect permeability of dentin and root canal treatment. However, most of studies have recommended the removal of this layer because it is the source of microorganism. Also its removal increase the adaptation and adhesiveness of root filling materials.

EDTA (ethylenediaminetetraacetic acid) is the most commonly used chelating agent which composed of 4 acetic acid groups attached to ethylenediamine. These acetic acid groups create stable calcium complexes with dentin, smear layer or calcnfic deposits along canal walls. This wiil aid in dissolving these calcific debris for easily flushing out the root canal. The effect of EDTA on dentin depends on its concentration and the contact time. With higher concentration and longer contact time its action is increase. Studies recommended 17% concentration with neutral pH for better decalcification results.

The functions and uses of ED TA:

1.Lubrication for easily manipulating instruments.

2.Emulsification and dentin dissolving properties which reduce canal debridement time.

3.It helps in enlarging narrow canals. 4 Smear layer removal for better adhesion and dentinal tubules penetration of root filling material.

Chlorhexidine

Broad spectrum antimicrobial agent and its activity is related to the cationic molecular structure, which can be absorbed by the anionic bacterial cell membrane and causes leakage of intracellular components.

Low concentration (0.2%) → bacteriostatic → mouth washes.

Higher concentrations (2%) → bactericidal → root canal irrigation.

Disadvantages:

1- Not be considered as the main irrigant in standard endodontic therapy.
2- It is unable to dissolve necrotic tissue remnants.
3- It is less effective on gram-negative than on gram-positive bacteria.

Methods of irrigation

There are different methods available in delivering and activating the irrigants within root canal:

- **Irrigation syringe and needle:**

Plastic syringe of different sizes (1 -20ml) are used for irrigation . The preferable sizes is between 15m! to maximize safety and control instead of larger syringes which required more pressure.

Although needle gauge 27 is the recommended size in many research, there are also smaller sizes available nowadays (30 and 31 gauge). The 27-6 is corresponding to size 0.42mm and 30-G to size 0.31. Also several modifications of the needle tip design have been introduced, such as rounded tips and side ‘ holes to facilitate moving irrigant sideway in the canal rather that pushing the irrigant apically to reduce side effects.

Disadvantages: the irrigant solutions cannot be pushed beyond the tip of the irrigation needle because of the dead-water zone or air bubbles trapping in the apical canal region.

- **Ultrasonic**

The use of ultrasonic energy for oscillating file with the present of irrigant have been shown to clean root canal better than conventional hand instrumentation. The ultrasonically oscillated file cause an energy which passes to the irrigant solution and exert “acoustic streaming or scrubbing’ effect on the canal walls. This mechanical energy dislodge the debris and smear layer from the canal walls.

Disadvantages:

1.Ultrasonic preparation of the canal is found to be unpredictable.

2.It can lead to excessive cutting of canal walls and may damage the finished preparation.

- **Sonic:**

The irrigation solution also can be activated sonically to create kinetic energy which could facilitate debridement of the root canal. EndoActivator is one of these irrigation facilitator methods. it is based on sonic vibration (up to 10,000 cpm) of a plastic tip in the root canal after delivery of the irrigant by using irrigation syringe.

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ENDODONTICS

Lect :10 Ass. Lec. Othman H. Alani

Obturation of root canal system

After chemo-mechanical debridement of root canal system by instrumentation and irrigation, the next step is complete (3 dimensional) obturation of root canal space to maintain the tooth functional within the dental arch.

The remaining non-vital pulp within incompletely debrided root canal will undergo autolysis and the disintegrated by products will diffuse into the surrounding tissue.

The fundamental aim of obturation is to provide 3 dimensional hermetic seal of root canal space to prevent the leakage from or into root canal system. The obturation method include the use of a solid or semisolid core material (gutta percha) surrounding by a sealer type of material to produce the fluid tight seat, by filling the main root canal(s), the accessory canals, voids, spaces and irregularities.

Aims of root canal obturation:

1-The achievement of 3 dimensional obturation of the root canal space to prevent ingress of bacteria and body fluids into root canal space, as well as egress of bacteria or their toxins out of the root canal.

2-To provide fluid tight seal within all regions of root canal space to prevent microleakage.

3-The replacement of the root canal space filled with necrotic tissue by an inert filling material to create a favorable healing environment and avoid recurrent infection.

4-To provide adequate coronal seal with proper coronal restoration to obtain long term success of root canal therapy.

- **Timing of obturation:** Several factors should be checked before doing obturation:

1- The sensitivity to percussion indicative that the inflammation of the periaplcal periodontal ligament is present. Therefore, the obturation has to be postponed until the inflammation subside. In cases of irreversible pulpitis with no tenderness to percussion present. The root canal treatment can be completed in a single visit as soon as the cause of the pain and inflammation has been removed.

2-Canal wettability :

Presence of wet canal with purulent exudate, blood or pus is a strong evidence that the periradicular inflammation is still present. Obturation of the root canal at this stage increase the pressure within periradicular region and subsequent tissue destruction may proceed rapidly. Therefore, in cases of active periradicuiar infection, delaying obturation until all signs and symptoms of inflammation have to be subside is extremely recommended.

3-**Negative culture:** most of the endodontist do not relay on this test because researches have approved that the false negative results inaccurately assess the intra-canal microbial flora. Furthermore, the positive results is not an indicative for the potential bacterial pathogenicity.

Features of an ideal root canal obturation:

1-Complete 3 dimensional obturation from the coronal orifice of the root canal until CDJ.

2-Radiographicaity, the root filling should be within 0.5-0.75 mm from radiographical apex.

3-The root canal should be completely filled, mainly with root filling material with a minimum amount of sealer.

Under filling: occur when the root canal filling is shorter that total root canal space. This definiteiy provide an environment for initiation, persistence or recurrence of periradicuiar infection.

Overfilling: occur when the root filling material extended beyond the CDJ. According to N9 et al. 2007 the extrusion of root canal filling is considered to be acceptable within 2mm beyond (longer than) the radiographical apex, if it is associated with 3 dimensional sealing of root canal system.

❖Characteristics of an ideal root filling material:

1-Easy introduced in the root canal.

2-Provide an apical and lateral sealing of the root canal.

3-Dimensionally stable after usage.

4-lmpervious to moisture.

5-Bacteriostatic or at least should not encourage bacterial growth

6-Radiopaque.

7-Non staining to tooth structure.

8-Non irritating

9-Sterile or easily sterilized.

10-Removed easily from canal if required.

Materials used for obturation

- Plastics: Gutta-percha.
- Solids or metal cores Silver points ,gold, stainless steel titanium
- Cements and pastes:

-MTA

-Gutta flow

- **<u>Gutta percha</u>**

Gutta percha :Is a natural material extracted as a dried coagulated from a Brazilian trees(PaIaqu1um) Its molecular structure is close to natural rubber. Chemically gutta percha is available into two crystalline forms: alpha and beta.

The most commercially available product is in B-form with composion following:

- Organic content: gutta percha 20% + waxes and resins 3%
- Inorganic: zinc oxide filler 66% + heavy metal sulfates as radiopacifiers 11%

<u>Forms of Gutta percha:</u>

Gutta percha available in different forms. The B-form is produced as gutta percha points (cones) which is available in different sizes and tapering as follow:

1-Standard cones of the same size and shape of the ISO endodontic instruments.

2-Greater taper gutta percha points: available with taper 4%, 6%, 8% and 10%.

3-Auxiliary points: non-standard cones.

Properties of gutta percha:

The Gutta percha expand on heating and increase volume which could be advantageous to compact into root canal spaces. However, Gutta percha shrink on cooling. Therefore, vertical pressure should be applied on warm gutta percha to compensate for volume loss after cooling.

- Heat sterilization is inapplicable with gutta percha. For disinfection, gutta percha points can be immersed in ethanol alcohol (96%) for one minute prior to its use.
- Because gutta percha has no adherence property, it should always be used with sealers to seal the root canal space.
- Gutta percha can be dissolved in certain chemical solvent such as chlorofom eucalyptus oil, etc. The chemically plasticized property of gutta percha is important in soften gutta percha points for better filling or in easily removal of gutta percha from the canal during re-endodontic treatment.

Advantages of gutta percha:

1-Compatibility: adaptation to the canal wall.

2-Inertness: do not interact with the tissue

3-Tissue tolerance.

4-Dimensionally stable.

5-Radiopacity.

6-Plasticity: can be soften either with heat or using chemical solvent

Disedvantages:

1-Lack of rigidity: can be bend easily with pressure which make its application difficult especially in narrow canals.

2-Lack of adhesiveness so it should be used with sealers and cements.

3-Easily displaced by pressure.

Silver points:

Old endodontic filling points which were made from silver. They are stiff points with rounded cross section, which can be easily used in rounded and narrow canals. However, because of their sliver corrosive products, which are toxic in nature, their use have been declined nowadays. In addition, silver points are not compatibles, lacking plasticity, and cannot adhere to the canal wall.

Root canal sealers:

Seaiers can serve several functions:

1-Lubricate and aid the seating of gutta percha cones.

2-Facilitate the bonding between gutta percha and root canal walls.

3-Filling the gaps and anatomical spaces where the primary filling cannot reach.

4-The combination between sealer and primary filling effectively increase the fluid tight seal and prognosis of endodontic treatment. However, there are some sealers (cements) that can be used as obturating material without gutta percha.

5-Antimicrobial agent: the germicidal property is exerted immediately after placement.

6-Radiopacity: this property helps to identify the presence of auxiliary canals, resorption regions, root fracture, and the shape of apical foramen.

Different types of sealers are available in the market such as: zinc oxide-eugenol formulations, calcium hydroxide sealers, glass ionomers, epoxy resin sealers, silicon sealers, bioceramics and medicated sealers. These types have different physical and biological properties. Therefore, a care should be taken to evaluate all characteristics of a sealer before selection.

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ENDODONTICS

Lect :10 **د .عثمان هشام العاني**

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3-Auxiliary points: non-standard cones.

Properties of gutta percha:

The Gutta percha expand on heating and increase volume which could be advantageous to compact into root canal spaces. However, Gutta percha shrink on cooling. Therefore, vertical pressure should be applied on warm gutta percha to compensate for volume loss after cooling.

- Heat sterilization is inapplicable with gutta percha. For disinfection, gutta percha points can be immersed in ethanol alcohol (96%) for one minute prior to its use.
- Because gutta percha has no adherence property, it should always be used with sealers to seal the root canal space.
- Gutta percha can be dissolved in certain chemical solvent such as chlorofom eucalyptus oil, etc. The chemically plasticized property of gutta percha is important in soften gutta percha points for better filling or in easily removal of gutta percha from the canal during re-endodontic treatment.

Advantages of gutta percha:

1-Compatibility: adaptation to the canal wall.

2-Inertness: do not interact with the tissue

3-Tissue tolerance.

4-Dimensionally stable.

5-Radiopacity.

6-Plasticity: can be soften either with heat or using chemical solvent

Disedvantages:

1-Lack of rigidity: can be bend easily with pressure which make its application difficult especially in narrow canals.

2-Lack of adhesiveness so it should be used with sealers and cements.

3-Easily displaced by pressure.

- **<u>Silver points:</u>**

Old endodontic filling points which were made from silver. They are stiff points with rounded cross section, which can be easily used in rounded and narrow canals. However, because of their sliver corrosive products, which are toxic in nature, their use have been declined nowadays. In addition, silver points are not compatibles, lacking plasticity, and cannot adhere to the canal wall.

- **Root canal sealers:**

Seaiers can serve several functions:

1-Lubricate and aid the seating of gutta percha cones.

2-Facilitate the bonding between gutta percha and root canal walls.

3-Filling the gaps and anatomical spaces where the primary filling cannot reach.

4-The combination between sealer and primary filling effectively increase the fluid tight seal and prognosis of endodontic treatment. However, there are some sealers (cements) that can be used as obturating material without gutta percha.

5-Antimicrobial agent: the germicidal property is exerted immediately after placement.

6-Radiopacity: this property helps to identify the presence of auxiliary canals, resorption regions, root fracture, and the shape of apical foramen.

Different types of sealers are available in the market such as: zinc oxide-eugenol formulations, calcium hydroxide sealers, glass ionomers, epoxy resin sealers, silicon sealers, bioceramics and medicated sealers. These types have different physical and biological properties. Therefore, a care should be taken to evaluate all characteristics of a sealer before selection.

ENDODONTICS

Lect:11 Ass. Lec. Othman H. Alani

Obturation Techniques

Different methods are available for obturating root canal system. This lecture: will focused on the following

1. Lateral compactioh technique.

2. Vertical compaction technique.

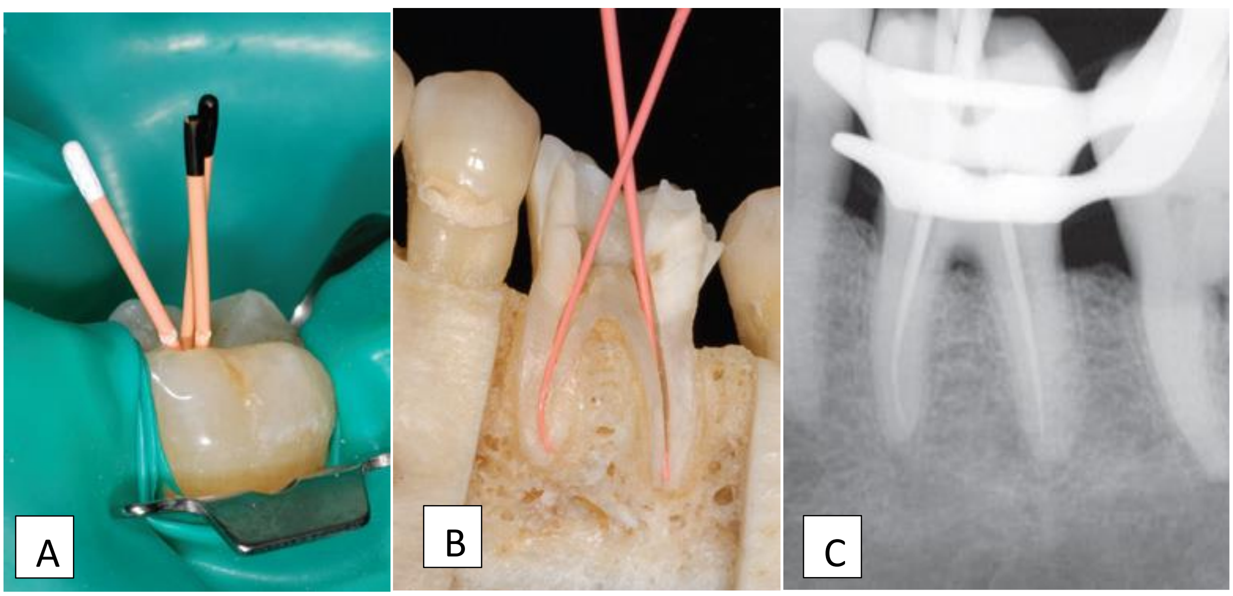
Armamentarium for obturation:

- Primary and auxiliary (accessory) cones of gutta percha.
- Absorbent paper point for dryness of the root canal after irrigation complete. These point are available with different sizes and tapering matching that of gutta percha cones.
- Spreaders and pluggers for compaction of gutta percha. These instrument also available in different sizes to tit the size of the prepared canal. The spreaders are either hand or finger spreaders with pointed tips and sizes starting from ISO size 20 to 45 or 50. The pluggers are mainly available with handles and flat tips to vertically compact the soften gutta percha. The tip sizes are available from 0.4 to 1.2mm.
- Endodontic ruler for measuring the length of gutta percha point.
- Scissor for cutting gutta percha points during fitting inside the canal.
- Heating device such as spirit lamp or gas torch.
- Heating instrument such as spoon excavator.

Lateral compaction technique:

The most common obturation compaction technique involves the placement of the master gutta percha point and accessories under lateral pressure against the canal walls by using a spreader. The canal should be continuously tapered shape with definitive apical stop. The procedure is as follow:

1-After canal preparation, select the master gutta-percha cone, whose size is consistent to the size of the largest file used in instrumentation up to the full working length. This gutta-percha cone is called **master apical cone (MAC)**. This cone have to fit to the full WL of the canal (Fig-1: A).



(Fig -1: A, B&C)

a-Should feel resistance when you pull the cone out of the canal. This resistance comes from the engagement of MAC between walls of the apical region of the prepared canal (3-5mm of the apical canal region). This feeling of resistance is called **tug back** (Fig-1: B). If the MAC fit the entire WL but no tug back, you can either choose larger cone size or cut 0.5 - 1mm from the cone tip until a tug back has to be fit. After that mark the WL on the MAC at the level of incisal or occlusal reference point. This can be done by making a notch on the MAC at this level (Fig-1: A).

b- Check the fit of MAF radiographically (Fig-1: C).

- If the master cone fit within canal WL, remove the cone from the canal and place it over a piece of cotton socked in either sodium hypochlorite or 96% ethanol.
- If the MAC fits shorter of the WL, check for any canal blocking by dentin chips, ledge or canal curvature and treat them accordingly.
- If the MAC going beyond the apical foramen, either select larger cone size or cut the cone to the WL.
- If the tip of MAC shows “8" shape in radiograph this means that the cone is too small for the canal. A larger size can be selected to fit the canal.

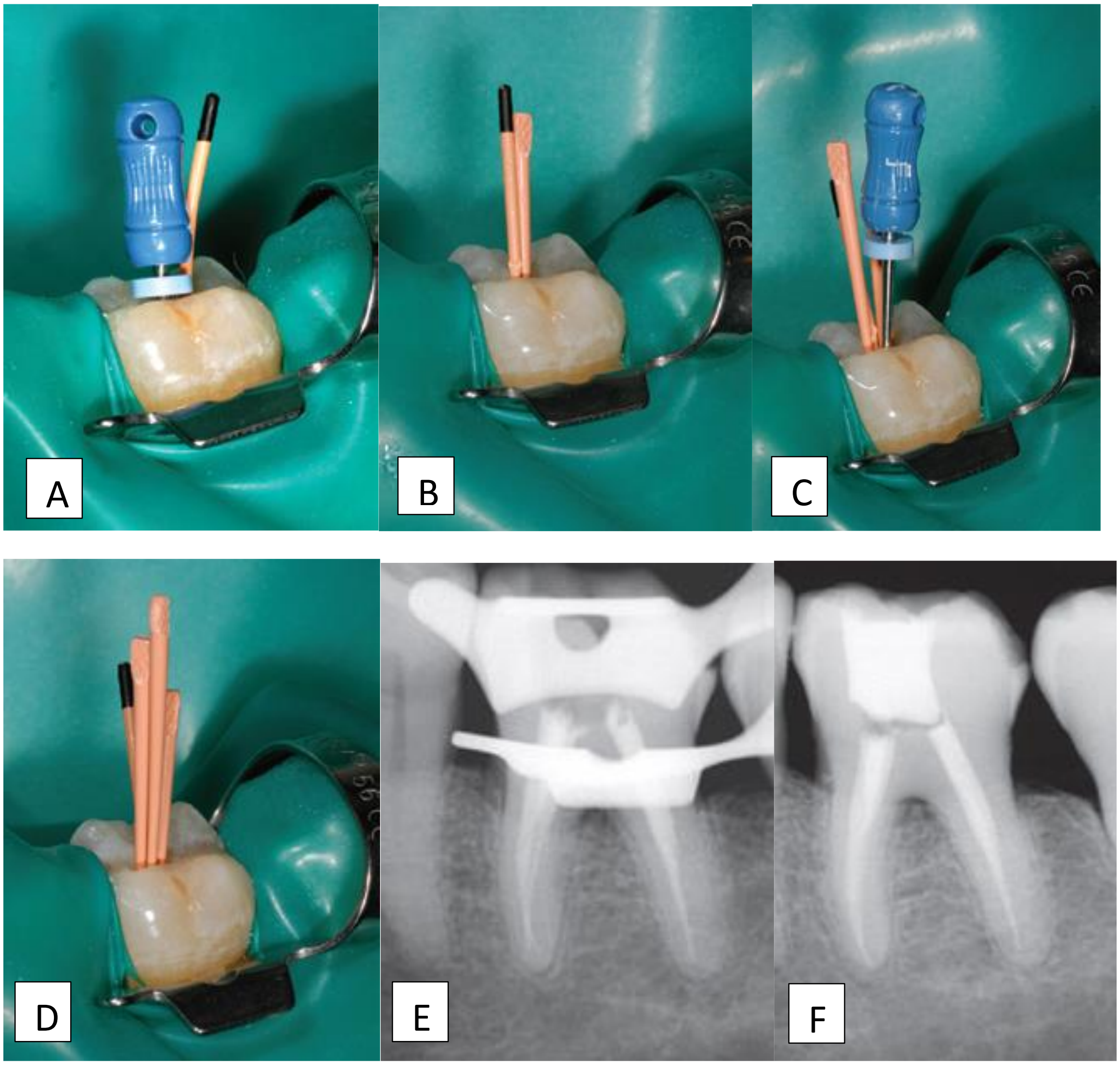
2-Select suitable size of a spreader to be used for lateral compaction, which should reach 1-2mm shorter of the canal WL.

3-Dry the canal completely with paper point.

4-Mix the sealer according to the manufacturer instruction and apply it within the canal either by a paper point or a clean file with counter clockwise rotation inside the canal .

5-Coat the measured MAC with small amount of sealer and place it inside the canal. The spreader then placed into the canal alongside the MAC with vertical gentle pressure. The spreader will act as a wedge to compact gutta percha laterally under vertical pressure on the wall of the canal (Fig 2: A)

After that the spreader can be removed from the canal by rotating it back. This will leave a space alongside the MAC for the accessory gutta percha.



(Fig .2: A, B,C,D,E&F)

An accessory cone can then be placed into the left space (Fig 2 :B) and the above procedure is repeated until the spreader can no longer penetrate beyond the cervical line (Fig 2: C&D).

Finally the cut the protruded parts of gutta percha points with hot instrument such as spoon excavator of the endo plugger (Fig 2 :E). A gentle vertical compaction can also be done by the plugger to seal the coronal orifice of the canal with the melted gutta percha (Fig 2: F).

Advantages of lateral compaction:

1-It can be used with the most routine clinical situations.

2-During lateral compaction, it provides length control with less chance of overfilling and post-operative pain.

Disadvantages:

1-May not sufficiently fill the irregularities within the canal.

2-Does not produce homogenous mass.

3-Voids and spaces may exist between accessory and master cones.

Vertical compaction technique:

This technique was introduced to overcome the drawbacks of lateral compaction technique. It uses hot plugger with vertical pressure to compact the heat soften gutta percha to flow into canal irregularities. The prepared canal that can be filled by this technique should have:

- A funnel shape with continuous tapering to the apex.
- Good apical stop region (apical constriction is as small as possible).

The procedure is as follow:

- ❖ Select the master cone gutta percha which should fit the canal size and taper, and check its fitness by radiograph.
- ❖ Dry the canal completely with paper point.
- ❖ Select the sizes of pluggers according to the size and taper of the canal. Pluggers should be pre-fitted at 5 mm intervals in order to capture maximum cross section area of the softened gutta percha.
- ❖ Coat the canal lightly with sealer by a paper point.
- ❖ Cut the coronal end of the gutta percha cone at the incisal or occlusal reference point.

- ❖ Use the heated plugger to vertically force the master cone into the canal. Fold the soften gutta-percha inward to fit apically and laterally. If the soften gutta percha stuck into the plugger tip, just slight rotate the plugger to loosen it. This vertical compaction will free 2-3 mm of space coronally to allow adding more gutta-percha.
- ❖ After finish the apical filling, complete obturation by doing backfilling. This can be done by heating small segment of gutta perch and carrying them into the canal using heated larger pluggers.
  - ✓ Be careful not to overheat the gutta-percha to facilitate its handling.
  - ✓ Don't apply more sealer into the soften gutta-percha because this will prevent the adhesion between the soften layers of gutta-percha.

- ❖ After completion, clean the pulp chamber from the excess of sealer and gutta-percha by a piece of cotton socked in alcohol then put the temporary or final restoration.

Advantages of the vertical compaction technique:

Provide excellent sealing of the canal apically and laterally with filling of the lateral and accessory canals.

Disadvantages

1- Increase the risk of vertical root fracture.
2- 2-Overfllling and apical extrusion of the gutta-percha and sealer periapically.
3- Time consuming procedure.

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Operative Dentistry

Lecture (2)

Patient Evaluation, Diagnosis and Treatment Planning

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 from 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. As studies have shown that tooth structure adjacent to GI cement restorations is less susceptible to caries; replacement of the restoration indicated when tooth structure adjacent to the marginal gap becomes carious or by 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 2mm 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 even in the absence of impingement on biologic width. 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 contact 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.

In 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). 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 restoration, a crown or indirectly fabricated onlay or resin composite.

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.

1. 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.

2. EVALUATION OF RADIOGRAPH

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

-Pervious 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.

3. **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

Biologic Consideration of Enamel and its Clinical Significance in Operative Dentistry

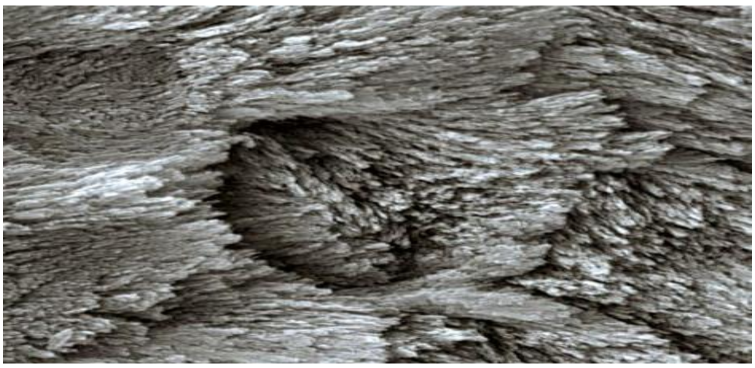
Enamel provides the shape and hard, durable outer surface of teeth, which protects the underlying dentin and pulp. Both color and form contribute to the esthetic appearance of enamel. Much of the art of restorative dentistry comes from efforts to simulate the color, texture, translucency, and contours of enamel with synthetic dental materials, such as resin composite or porcelain. Enamel is formed by cells called ameloblast.

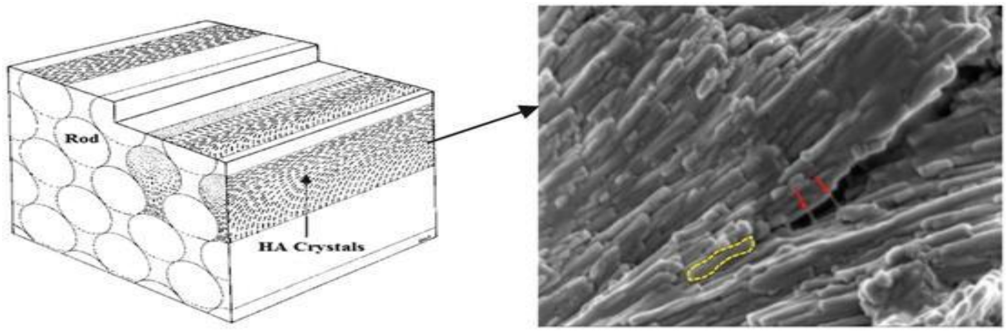
Enamel is incapable of repairing itself once destroyed because the ameloblast cell degenerates after formation of enamel rod. The final act of ameloblast cell is secretion of a membrane covering the end of enamel rod. This layer is referred to as Nasmyth membrane or the primary enamel cuticle, which 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.





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 per square millimeter of a surface of cut enamel, and the etch penetration increases the bondable surface area 10-to20-fold, the attachment of resin adhesives to enamel through micromechanical interlocking is extremely strong

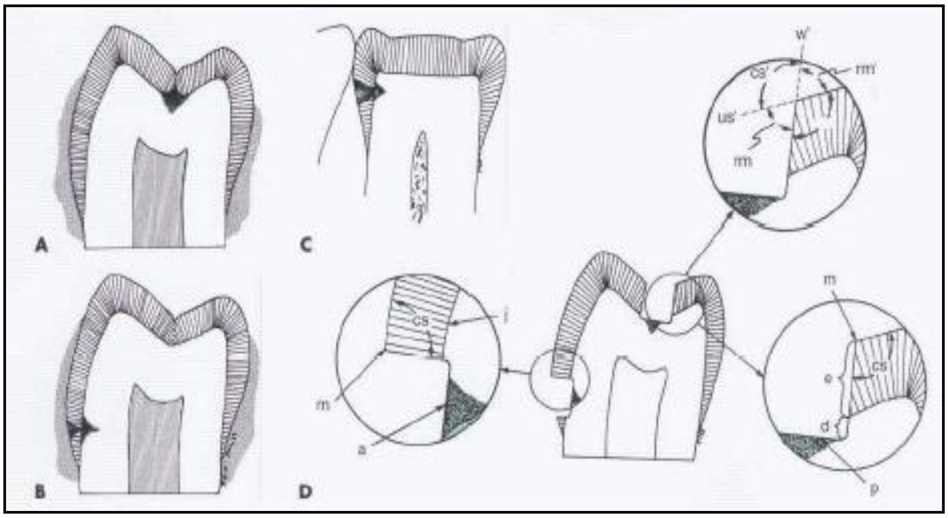
Acid-etch modification of enamel for restoration retention provides a conservative, reliable, alternative to traditional methods of tooth preparation and restorations (retentive grooves, pins, extension for prevention...).

Resin bond strengths are twice as high when adhering to the acid-etched ends of the crystals as compared with the sides of the crystals. Thus, a bevel of approximately 45 degrees across a 90-degree cavosurface angle of a prepared cavity will expose the ends of the rods and their rod crystals. Beveling enamel cavosurface angles of cavity preparations for resin composite is generally recommended to expose the ends of the rods and to maximize the integrity of the restoration at its margins.

Starting at 1mm from the CEJ, the rods on the vertical surfaces run occlusally or incisally at approximately a 60 degree 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.

Loss of enamel rods that form the cavity wall of cavo-surface margin of dental restorations 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 bevel or parallel the direction of enamel rods 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.



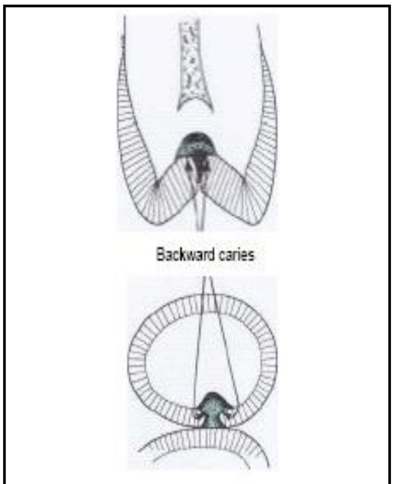


FIG . 6-3 Backward caries extends from DEJ into *enamel.*

Properties of Enamel

1. *Hardness*

Enamel is the hardest substance of human body. The hardness value of enamel (HV = 275) is around 4 to 5 times higher than that of dentin (HV = 65)

2. *Brittleness*

Enamel is very brittle; thus it requires a 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. *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.

4. *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 and incisal edges and decreases below deep fissures and become thin cervically at the junction with cementum.

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 (less than 1% by weight).

5.Permeability

At maturity, enamel is 96% inorganic hydroxyapatite mineral by weight and more than 86% hydroxyapatite mineral by volume. Enamel also contains a small volume of organic matrix, as well as 4% to 12% by volume water, which is contained in the intercrystalline spaces and in a network of micropores opening to the external surface.

Various fluids, ions, and low molecular weight substances, whether deleterious, physiologic, or therapeutic, can diffuse through the semipermeable enamel. Therefore, the dynamics of acid demineralization, reprecipitation or remineralization, fluoride uptake, and vital bleaching therapy are not limited to the surface but are active in three dimensions.

When teeth become dehydrated, as from nocturnal mouth breathing or rubber dam isolation for dental treatment, the empty micropores make the enamel appear chalky and lighter in color. The condition is reversible with return to the "wet" oral environment. There is some evidence that the permeability of the enamel decreases with age and may be affected by various dental procedures, such as tooth whitening, acid etching, or the physical removal of the outermost layer of enamel.

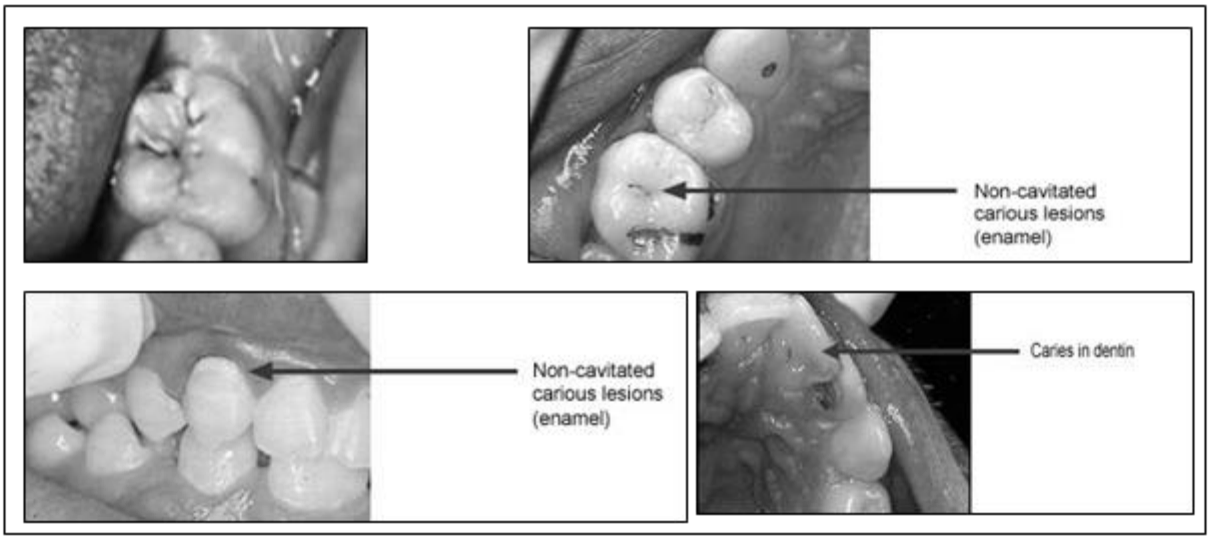
The yellowing of older teeth may be attributed to thinning or increased translucency of enamel, accumulation of trace elements in the enamel structure, and perhaps the sclerosis of mature dentin. This yellowing may be treated conservatively with at-home or in-office bleaching.

Clinical appearance and defects

The dentist must pay close attention to the surface characteristics of E. for evidence of pathologic or traumatic conditions. Key diagnostic signs include color changes associated with demineralization, cavitation, excessive wear, morphologic faults or fissures, and cracks.

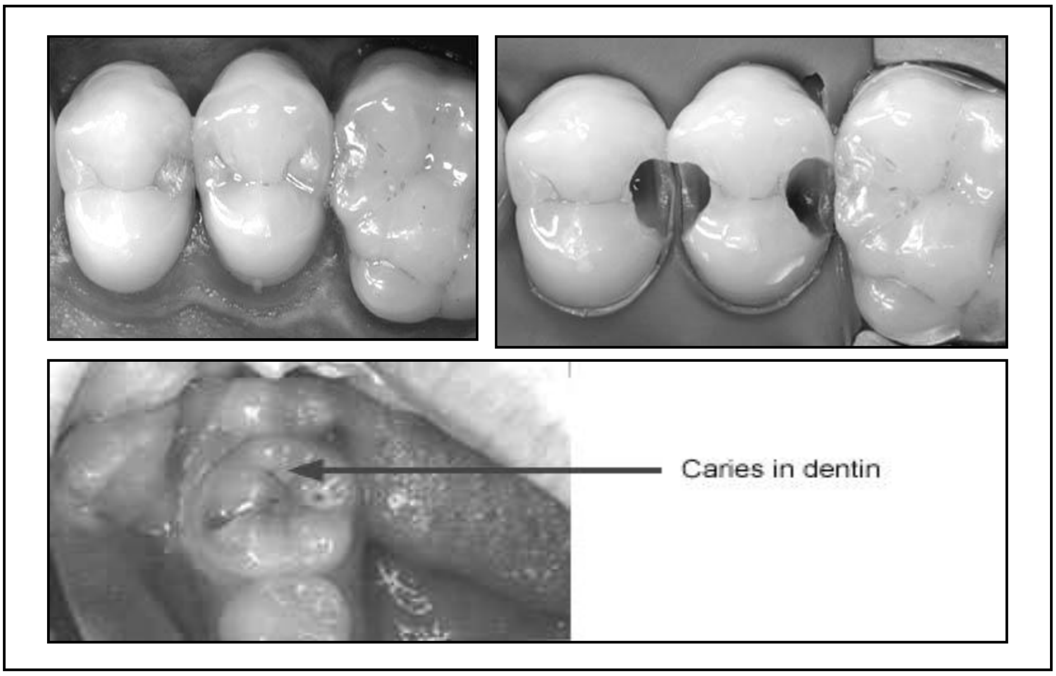
1. Color changes associated with demineralization

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.



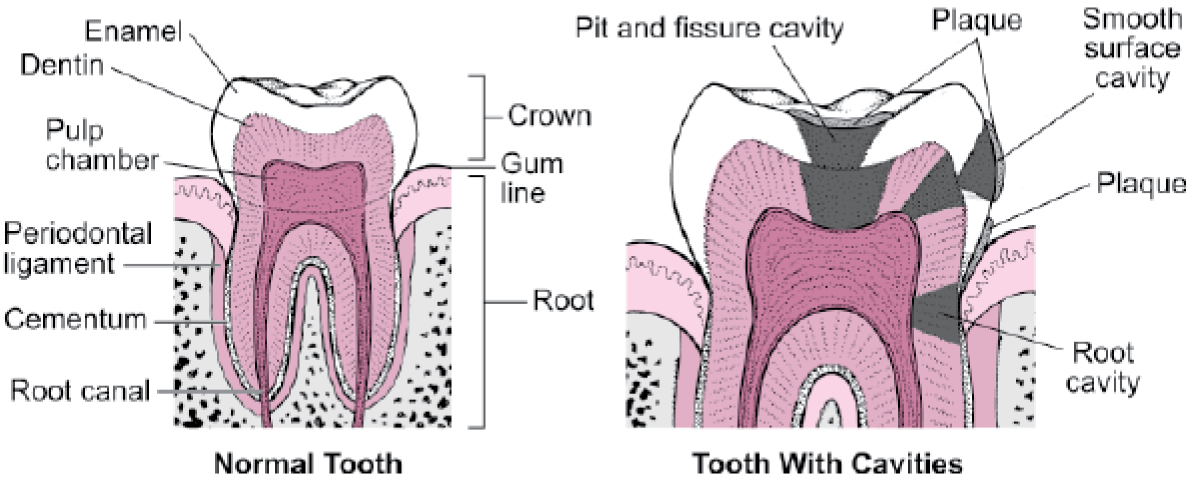
2. Cavitation

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.



When caries seen in a radiograph, the proximal enamel lesion is a cone with its base equivalent in location and area to the demineralized enamel surface and its apex closest to the DEJ.

Fissure-caries lesion presents with the apex of the triangular-shaped lesion located where the initial demineralization occurs simultaneously in both of the opposing internal surfaces of the occlusal fissure, and as the caries process follows the divergent rods of both opposing lobes toward the dentin, the lesion widens to form a broader base that parallels the DEJ.



Along with regular plaque removal, topical fluoride applications help to limit or even reverse enamel demineralization.

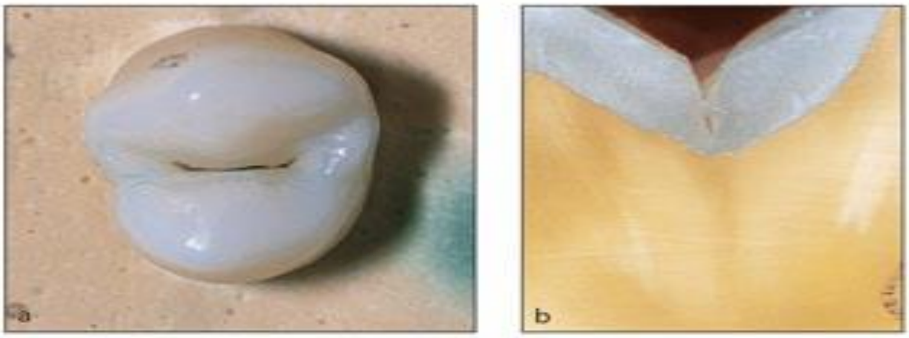
3. Wear

Enamel is as hard as steel, however enamel will wear because of attrition or frictional contact against opposing enamel or harder restorative materials such as porcelain. 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. So cavity outline form should be designed so that the margins of restorative materials avoid critical high stress areas of occlusal contact.

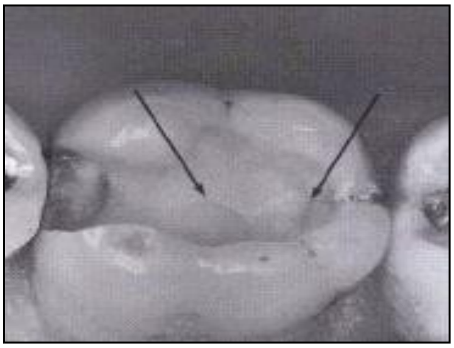
4. Faults and fissures

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 coronal or 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.



Management of Deep Seated Caries

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.

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

I-Protective Base:

A protective base 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 protective base such as calcium hydroxide and glass ionomer cement is at the dentist's discretion.

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 base may be placed between the permanent restoration and the dentin to minimize pulp injury, promote pulp tissue healing, or minimize postoperative sensitivity.

Objectives: A protective base 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

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. This is especially applicable if micro-exposures of the pulp are suspected. 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 caries-free can be assisted by using a caries disclosing solution.

The placement of a suitable material directly on this demineralised dentin is commonly called indirect pulp capping (IPC).

IPC has been defined as the steps undertaken to protect a vital tooth where removal of all affected tissues would result in a pulpal exposure.

In this context a non-exposed pulp is one that exhibits no signs of haemorrhage at or near the pulp chamber. When carrying out such a procedure it is vitally important that the infection is removed and is not allowed to recur.

Material used for IPC

1) This can be achieved with the placement of an antibacterial liner such as calcium hydroxide 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 cement followed by an adhesive liner 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 (1PC):

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 4 - 6 W (3 months) or more Cement removed.
7. Internal surface of the cavity inspected for remineralization and hard dentin (2nd 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 noncarious 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. Pre-operative tooth sensitivity frequently has been mentioned as a contraindication to Pulp capping.

Requirements for a successful vital pulp therapy

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

(1) The pulp is not inflamed;

(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.

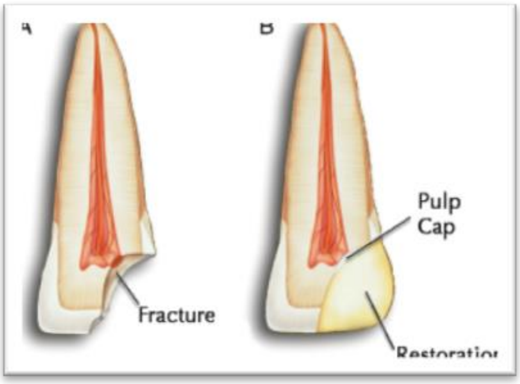
A major disadvantage of calcium hydroxide materials

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
3. Calcium hydroxide materials tend to soften, disintegrate, and dissolve over time, leaving voids and other potential pathways for bacterial infiltration .

Therefore, various other materials, including zinc oxide eugenol, glass ionomers, resin adhesives, and mineral trioxide aggregate (MTA), have been proposed as capping agents for vital pulp therapy. MTA is an alkaline material that stimulates dentinal bridging and appears to have particular promise as a pulp-capping material.

(4) The bacteria seal out base and restoration.

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 to 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 necrosis 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.

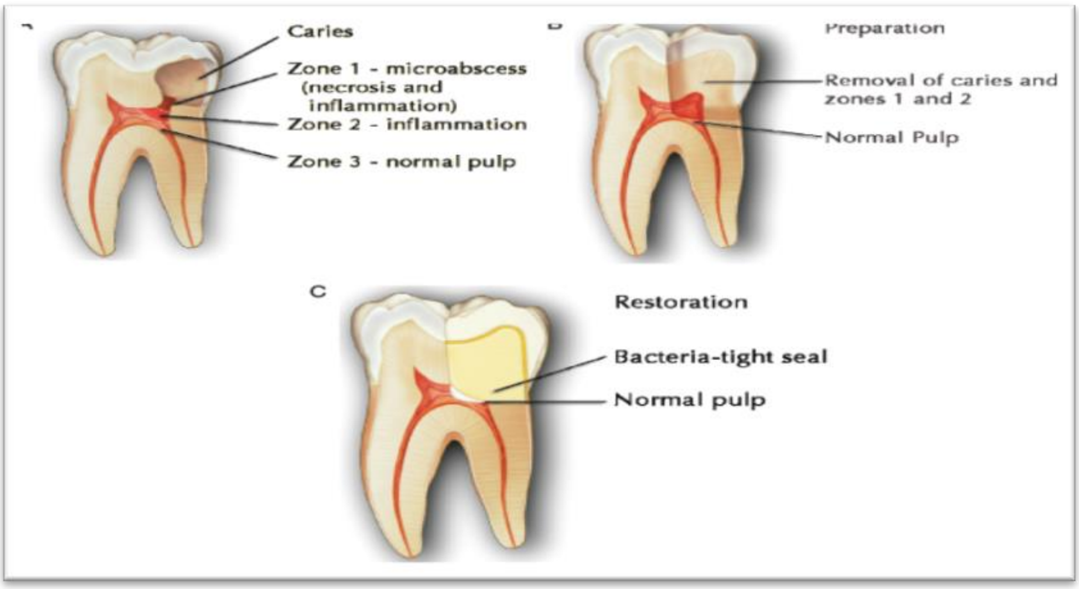
Indications

Indications for a partial pulpotomy are similar to those for direct pulp capping. 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 s 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.

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.

If the pulp is large enough to allow an additional 1– 2mm loss of tissue through necrosis, 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.

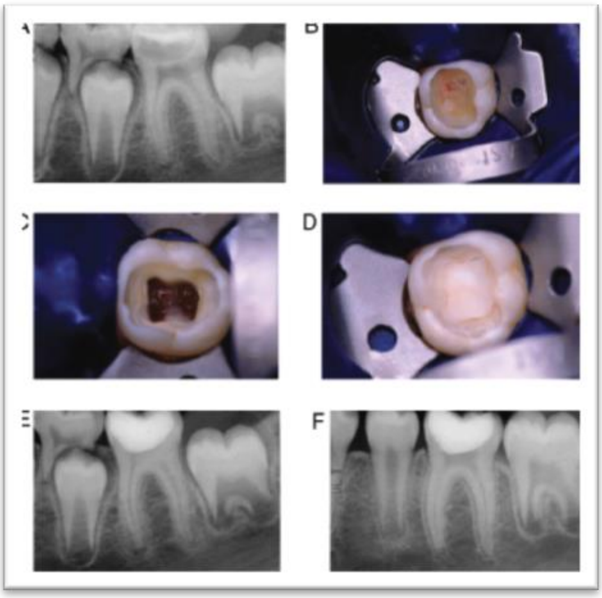
V- Full pulpotomy

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, but as much as 2–3mm apical to the 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.

OPERATIVE DENTISTRY

Biologic Consideration of Dentin and its 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.

Dentin is primarily composed of small, thin apatite crystal flakes embedded in a protein matrix of cross-linked collagen fibrils. 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.

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

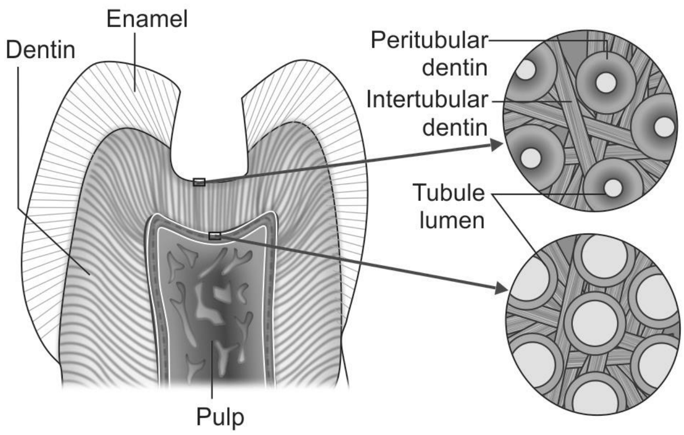
There are two main types of dentin which are:

1.Intertubular dentin: the structural component of the hydroxyapatite-embedded collagen matrix forming the bulk of dentin structure between tubules.

2.Peritubular dentin: the hypermineralized tubular walls.

Peritubular dentin has little organic matrix but is densely packed with apatite crystals

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, root planning, preparation with burs or abrasion and erosion, the exposed tubules become conduits between the pulp and the external oral environment. There are also regional differences in dentinal permeability. The coronal occlusal dentin (pulpal floor of a cavity preparation) is inherently less permeable than is the dentin around the pulp horns or axial surfaces. gingival areas of preparations, such as prepared proximal boxes or crown margins, which are relatively more susceptible to microleakage and development of recurrent caries lesions, are located where the dentin is most permeable. 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.

Dentinoenamel junction:

The transition between the highly mineralized enamel and the collagen-containing dentin is a complex junction of two structurally different tissues. This interface, the DEJ, must resist fracture and separation under the extreme forces from occlusal loading. *A soft zone* of dentin that transitions from the bulk dentin into the DEJ complex, which includes the mantle layer of dentin, may play a significant role in providing a cushioning soft layer between the enamel and bulk dentin of the tooth.

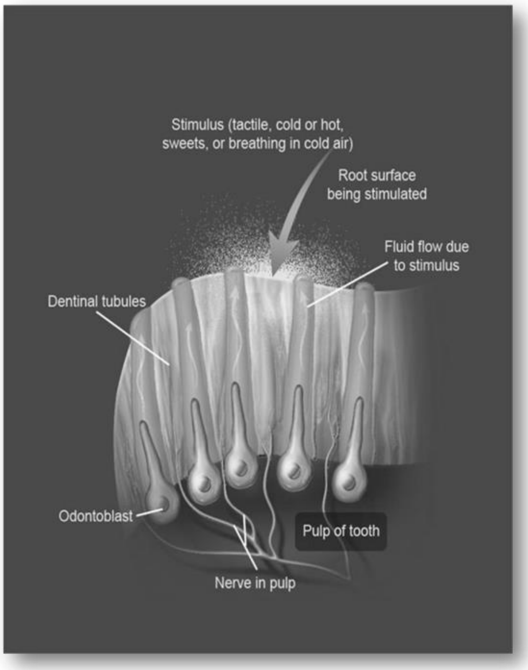
Theories of thermal sensitivity

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: The first-formed, primary dentin subjacent to the enamel is termed *mantle dentin*. It differs from other primary dentin in that it is 4% less mineralized. Following mantle deposition, odontoblasts begin to form odontoblastic processes and create tubules .When mature, as long as the root apex remains undeveloped and open, the odontoblasts produce primary dentin, mainly intertubular dentin, .

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.

Carious dentin

The caries process is driven by the presence of a biofilm containing acid-producing bacteria on the tooth surface. Without intervention, a progression of destructive changes occurs, prompting pulpal and dentinal responses. In contrast to enamel, dentin demineralization is more rapid because of the tubular network and the high surface-to-volume ratio of the small hydroxyapatite crystallites embedded in the collagen. Incipient, noncavitated lesions may be arrested with plaque control or with other noninvasive preventive therapies.

Clinically, the affected dentin is often distinguished from normal dentin by decreased hardness and by a yellow-brown discoloration due to acid effect on the organic dentin matrix or possibly from exogenous staining. Clinically, advanced or acutely infected dentin differs from normal dentin or dentin of an arrested caries lesion in that it is soft, readily excavated, wet, and generally light yellow to orange in color. This amorphous lesion is referred to as infected dentin and histologically as the zone of destruction.

Beneath this zone, where the dentin matrix is still intact and limited bacterial penetration is confined to the tubules, the dentin is termed affected dentin. In the event of cavitation and dentinal infection, restorative treatment is necessary to remove the infected dentin and restore the integrity of the coronal surface. Discoloration is an unreliable guide to excavation of carious dentin, but the degree of dentin hardness, as determined by tactile feedback from excavating burs and hand instruments, is the most reliable guide to differentiation between infected, affected, and normal dentin.

Sclerotic 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. Sclerotic dentin is characterized by hypermineralization or blockage of the tubules and by a denatured collagen network.

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

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2. Pulp capping should be considered only for immature permanent teeth, or for mature permanent teeth with simple restorative needs.
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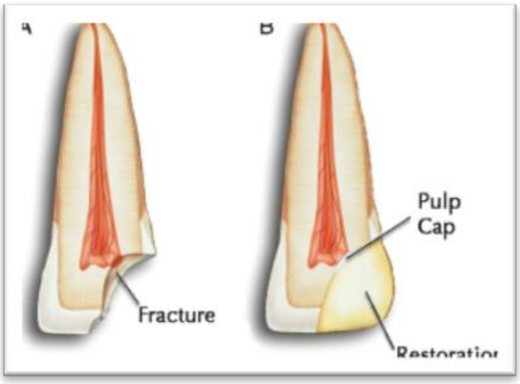


2. Mix pure calcium hydroxide with sterile water, saline, or anesthetic solution, and apply directly to the exposure site. A hard-setting calcium hydroxide liner also can be used, and is preferable if the pulp is small.
3. Next, apply and light-cure a resin modified glass ionomer base/liner material such as to protect the calcium hydroxide dressing and to provide a better seal.
4. Finally, use a good temporary and wait for 4 to 6 weeks for final resoration.

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 necrosis 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.

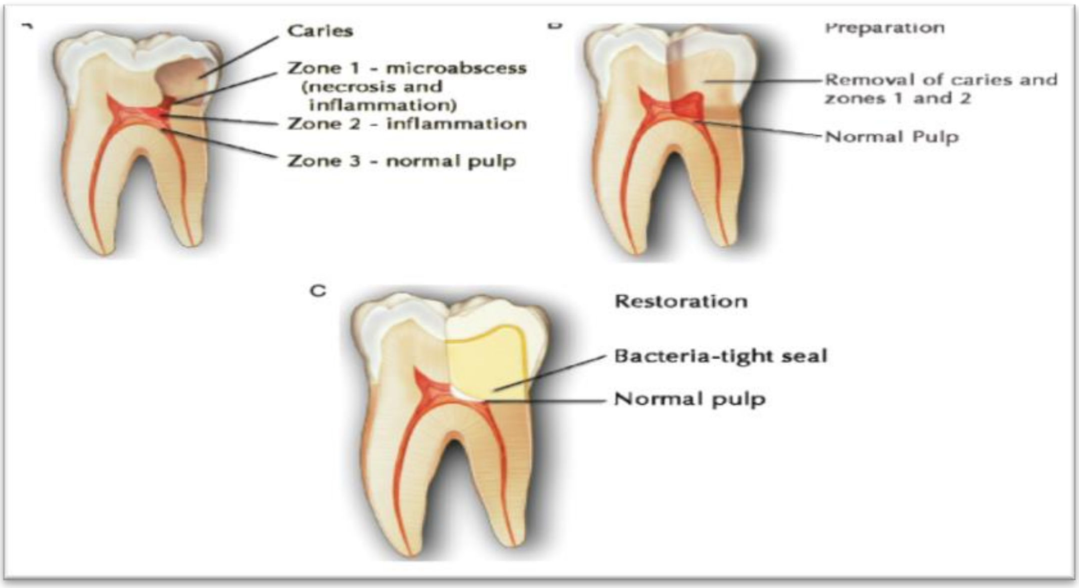
Indications

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 s 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.

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.

If the pulp is large enough to allow an additional 1– 2mm loss of tissue through necrosis, 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.

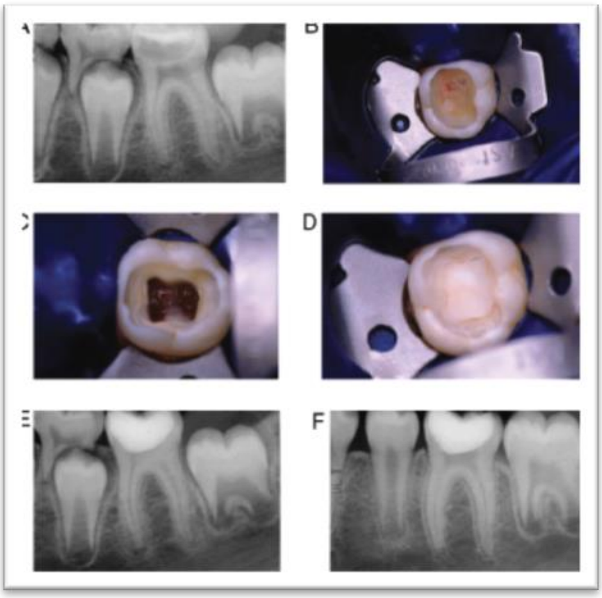
V- Full pulpotomy

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, but as much as 2–3mm apical to the 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.

OPERATIVE DENTISTRY

Lecture (6)

Caries Management: Diagnosis and Treatment Strategies

CARIES DETECTION AND DIAGNOSIS

The primary objective of early detection of caries is to limit the progression and impact of the disease after onset at as early a stage as possible. This objective is based on the fact that caries is reversible as well as preventable.

Detection of carious lesions must be done while the teeth are clean & dry:

Visual examination

The first clinical sign of caries is a chalky and matte (rough) whitish surface (*white spot lesion*) this white spot is a porous surface that can easily be stained into brown or black discoloration by chromogens from foods; thus, a caries lesion can be seen either as a white or as a brown/black spot lesion. There are noncavitated and cavitated stages of dental caries that can be identified and described using clinical signs.


***Clean tooth**. Most often the tooth is covered by a film of bacterial plaque that can camouflage a suspect lesion. It is necessary before caries detection that the plaque be removed gently with the explorer; detection may also be carried out immediately following prophylactic cleaning.

***Dry tooth**. The teeth should be thoroughly dried with an air-water syringe (> 5seconds) before all surfaces are carefully examined. The presence of saliva on tooth surfaces interferes with the detection of white spot lesions because of optical phenomena resulting from differences in the refractive indices of water (1.33), enamel (1.62) and air (1.0).54 A white spot lesion is a porous surface, and the pores are filled with saliva when the lesion is wet.

***Magnification and lighting.** It has been demonstrated that the accuracy of visual caries detection can be improved 50% with the use of a magnifying device, such as a prism loupe or a surgical microscope. Good lighting aids vision.

1. <u>Pit & fissure lesions:</u> detection of these lesions most often done 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. Bite-wing radiographs can detect only large occlusal lesions. 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.

2. <u>Lesions involving proximal surfaces:</u>

- 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.

- Fiberoptic transillumination techniques have proven useful. In these techniques, a fine light is transmitted through the contact area. Lesions appear as a dark shadow.
- 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.

3. Lesions in smooth free surfaces: lesions in smooth free surfaces whether in the enamel of the crown or the dentin of the root can be detected easily with visual examination.

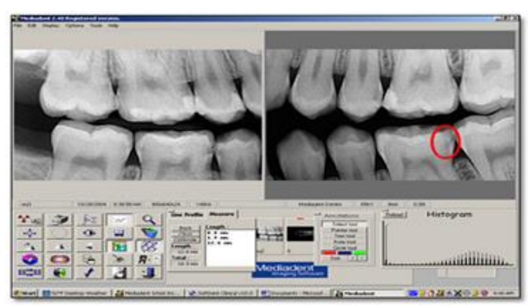
4. Root surfaces: Root surfaces exposed to the oral environment, usually due to gingival recession, are at risk for caries and should be examined visually and tactilely. Discoloration of such areas is common and usually is associated with remineralization. Generally the darker the discoloration, the 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 Devices

The development of several new devices and detection methods is promising.

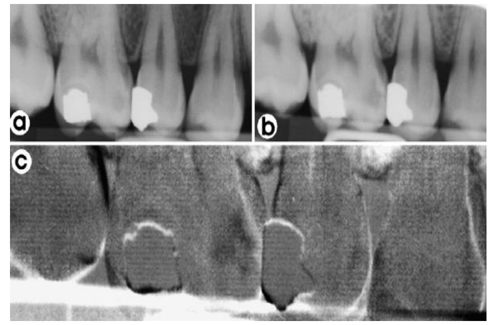
1. **Electronic caries monitors** are based on the principle that porous carious lesions have lower conductive values than intact tooth structure (for example: CarieScan system).

2. **Direct digital radiographs** for caries detection. This systems 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.



Subtraction radiography

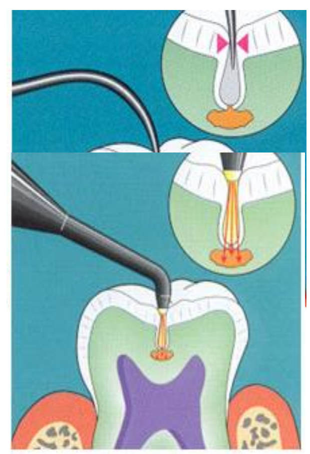
Used for detection of recurrent caries The basis of subtraction radiology is that two radiographs of the same object can be compared using their pixel values. any differences in the pixel values must be due to change in the object.



3. **<u>Intra-Oral camera</u> for caries detection and for patient motivation.**
4. **<u>Magnification using Loupes, and Dental Microscope.</u>**

5. **<u>Infrared Laser Fluorescence (DIAGNOdent)</u>**

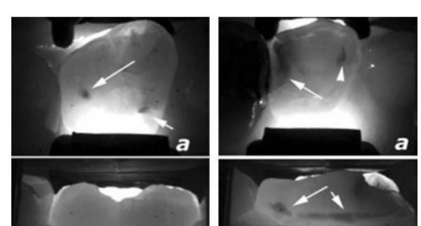
The principle is that cariogenic bacterial metabolites exhibit increased fluorescence causing change in the fluorescence of the lesion.



The **higher** the number the more is the caries
Advantage: the most useful in confirming the presence of caries in suspicious fissure and detecting deep dentinal caries (hidden caries). However, it is not used for the detection reccurent caries or to detect proximal caries.

6. **<u>Fiber-optic transillumination</u>**

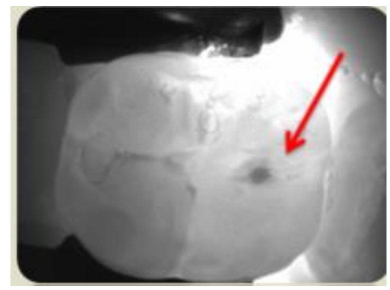
Fiber-optic transillumination (FOTI) as a caries detection technique is based on the fact that carious enamel has a lower index of light transmission than sound enamel.The intact tooth absorbs very little light allowing it free passage. In contrast areas of caries absorb and scatter light thus appear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



This method is mainly used to determine proximal caries

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.can not detect small lesions

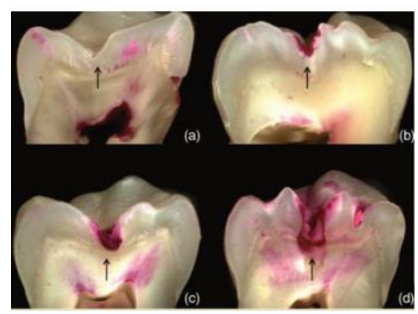
CariVu is a brilliant new approach to caries detection combining FOTI with a digital camera



7. **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.



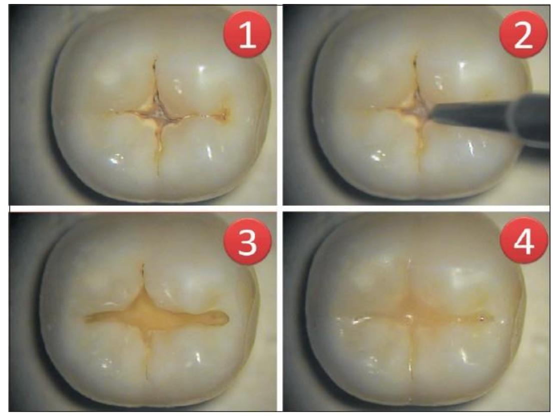
Caries Prevention and Treatment

Caries preventive treatment is a complex process involving multiple interrelated factors. Maintaining of good oral hygiene "brushing and flossing", diet containing sucrose and carbohydrate control, and fluoride treatment; all these factors can affect carious lesion initiation and also remineralization of the incipient carious lesion specially in smooth surfaces to arrested carious lesions. Pit and fissure sealant is the most effective method in preventing pit and fissure caries.

Once caries has produced cavitation of the tooth surface, preventive measures are usually inadequate to prevent further progression of caries. So, cavity preparation and restoration are needed. Once the pulp is dead partially or completely; root canal filling become necessary to avoid tooth extraction.

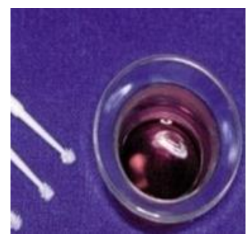
	Active	**Arrested**
Occlusal lesion	-Frosted surface, plaque covered white spot lesion. -cavitated lesion; include micro cavities to cavities involving dentine which is visible on bitewing radiograph.	-shiny surface white or brown spot lesion
proximal	-appear on radiograph -appear on radiograph with persistent gingival inflammation despite pt. attempt to remove plaque by flossing. -lesion not present at previous examination.	-accurate bitewing radiograph shows no lesion progression.
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 dentine is heavily infected..	- shiny surface white or brown lesion & lesions are not plaque covered. - cavitated lesion; dark brown & hard dentine at their base, are not plaque covered & away from gingival margin.
Root surface lesion	- close to gingival margin, plaque covered. -soft or leathery consistency	- far from gingival margin, not plaque covered. -as hard as surrounding healthy root surface.

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



1. **Air abrasion:** air abrasion removes tooth structure 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.



2. **Chemo mechanical method:** this method involves the application of an isotonic solution on tooth tissue, softening the caries and facilitating its removal using specially design hand instrument. This reduces the removal of sound tooth structure, the cutting of open dentinal tubules, pulpal irritation and pain compared with conventional mechanical method. (Example is cariosolv).

3. **Laser devices:** laser devices that are capable of cutting dental hard tissues effectively and can be used for operative procedures, 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.

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.

Operative Dentistry

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 severty of the stimuli. The effects of 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)

Pulpal responses to cutting procedure depend on many factors:

1- Thermal injury (frictional heat)

In spite of 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 deep cavity by continuous cutting without proper cooling, the underlying pulp may be severely damage. 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 temperature rise in the pulp:

a. Force applied by the operator is directly proportional with 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 water cooling system are (1) reduction of temperature rise, (2) removal of debris, and (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 increase in heat and vibration.

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

d. Duration of actual cutting time:

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

2-Transection 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 amputation of odontoblast process occur close to the cell body, this will lead to irreversible injury. Also during cutting procedure there is a distrubs 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.

3-Dehydration

When the surface of freshly cut dentin is dried with a jet of air there is a rapid out ward movement of fluid through the dentinal tubules. According to theory of dentin sensitivity, this movement result in stimulation of the sensory nerve of the pulp and drawing odontoblasts up into tubules, these displaced odontoblasts soon die and disappear as they under go autolysis result in an inflammatory response.

4-Remaining dentin thickness (RDT)

Dentin permeability increases with increasing cavity depth due to the differences in size and number of dentinal tubules. 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 replacement of lost tooth structure with cavity liner and base.

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 shallow cavity).injury to the pulp appears to be due to bacterial cavity contamination, so carious exposure result in much more bacterial contamination than dose mechanical 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 pulpalgia when anesthesia wears off. Radiographic revels the exposure and cement force into the pulp.

6-Pin insertion

Since the advantages of pin placement into dentin is to support amalgam and composite restoration or as a fram work for building up 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 severe irritant.

-Craze and stress in dentin during insertion.

C-Effect of lining materials and procedure

- ZPC: 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 of blood flow and cause pulpal death).
- Polycarpoxylat cement less irritant than ZPC, the lower level of irritation may be due to the large molecular size of polyacrylic acid which restricts penetration through dentin.adapted well to dentin and has bacteriocidal effect.
- ZOE apalliative effect, PH (7), bacteriostatic and cidal, has 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.
- GIC 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 irritant.

-Thickness of base materials should be (1-2mm) is an effective barrier against both hot and cold stimuli in 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 result 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 great number of pulp death.

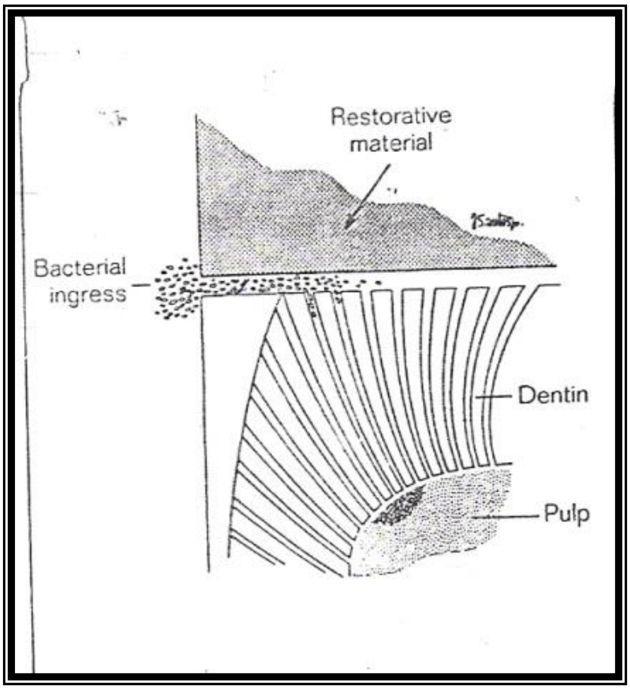
Composite resins: they give off irritant component, over along time than cold cure, the composite contain acrylic monomers in their catalyst system and it can be assumed that the monomers could be the cause of damage as in case of cold-curing resin.

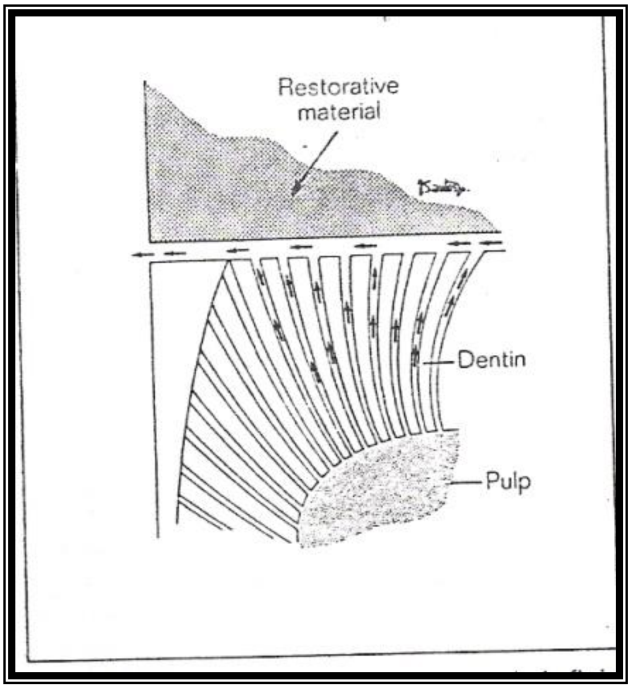
Acid etching: there is no significant effect of the acid on the pulpal microvascular vessels. But the acid etching widens the opening of dentinal tubules that increase the dentin permeability, and enhance bacterial penetration of dentin.

Dental amalgam: high mercury content amalgam may exert a cytotoxic effect on the pulp, the mercury penetrates into the dentin and pulp beneath an amalgam restoration. Patient some time 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 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 its better that these cement have ability to inhibit bacterial growth (eg;ZOE, GIC).





Two important factors affecting marginal adaptation: 1-temperature changes, 2-masticatory forces. If a material has different coefficient of thermal expansion than tooth structure, temperature change is likely to produce gaps between the material and the cavity. In composite filling, 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 get 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.

Heat of polishing: the pulp damage caused by polishing restoration 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.

Operative Dentistry

د. عثمان هشام العاني

Lecture (6)

Dental adhesion (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 tooth structures (enamel and dentin).

Requirements of Dentin Bonding Agents

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. Minimize microleakage at the margins of restorations.
5. Prevent recurrent caries and marginal staining.
6. Be easy to use.
7. Possess a good shelf life.
8. Be 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.

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.

Usually 37% phosphoric acid is used for 15 to 30 seconds.

The goals of enamel etching are 1) to clean enamel surface from debris, 2) to increase the enamel surface area available for bonding, and 3) to partially dissolve the mineral crystallites to create retentive microporosities into which the resinous bonding agent can infiltrate and form retentive resin tags (micromechanical retention). 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.

Procedure

Apply acid etchant in the form of liquid or gel for 15 to 30 seconds.

• Wash the etchant continuously with water for 10 to 15 seconds.

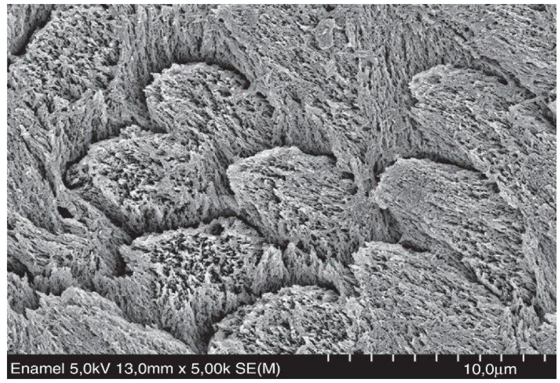
• Note the appearance of a properly etched surface. It should give a frosty white appearance on drying.

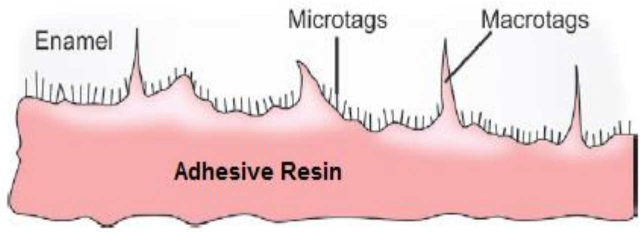
• If any sort of contamination occurs, repeat the procedure.

• Now apply bonding agent and low viscosity monomers over the etched enamel surface. Generally, enamel bonding agents contain Bis-GMA or UDMA with TEGDMA added to lower the viscosity of the bonding agent. The bonding agents due to their low viscosity, 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.





Enamel Etching and Bonding

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.

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.

Ideally a dentin bonding agent should have both hydrophilic and hydrophobic ends. The hydrophilic end displaces the dentinal fluid to wet the surface. The hydrophobic end bonds to the composite resin.

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.

Classification of Dentin Bonding Agents

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.

Fourth Generation Dentin Bonding Agents

They were made available in the mid 1990s. Fourth generation bonding agents represented significant improvements in the field of adhesive dentistry. These agents are based on total etch technique (now it is called etch and rinse 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.

Components of Fourth Generation Adhesives

1. **Conditioner (Etchant):** Commonly used acids are 37% phosphoric acid, nitric acid, maleic acid, oxalic acid, pyruvic acid, hydrochloric acid, citric acid or a chelating agent, e.g. EDTA.

Use of conditioner/etchant causes removal or modification of the smear layer, demineralizes peritubular and intertubular dentin and exposes collagen fibrils.

2. **Primer:** Primers consist of monomers like HEMA (2-Hydroxyethyl methacrylate) and 4-META (4-Methacryloxyethyl trimellitate anhydride) dissolved in acetone or ethanol. Thus, they have both hydrophilic as well as hydrophobic ends which have affinity for the exposed collagen and resin respectively. Use of primer increases wettability of the dentin surface, bonding between the dentin and resin, and encourages monomer infiltration of demineralized peritubular and intertubular dentin.

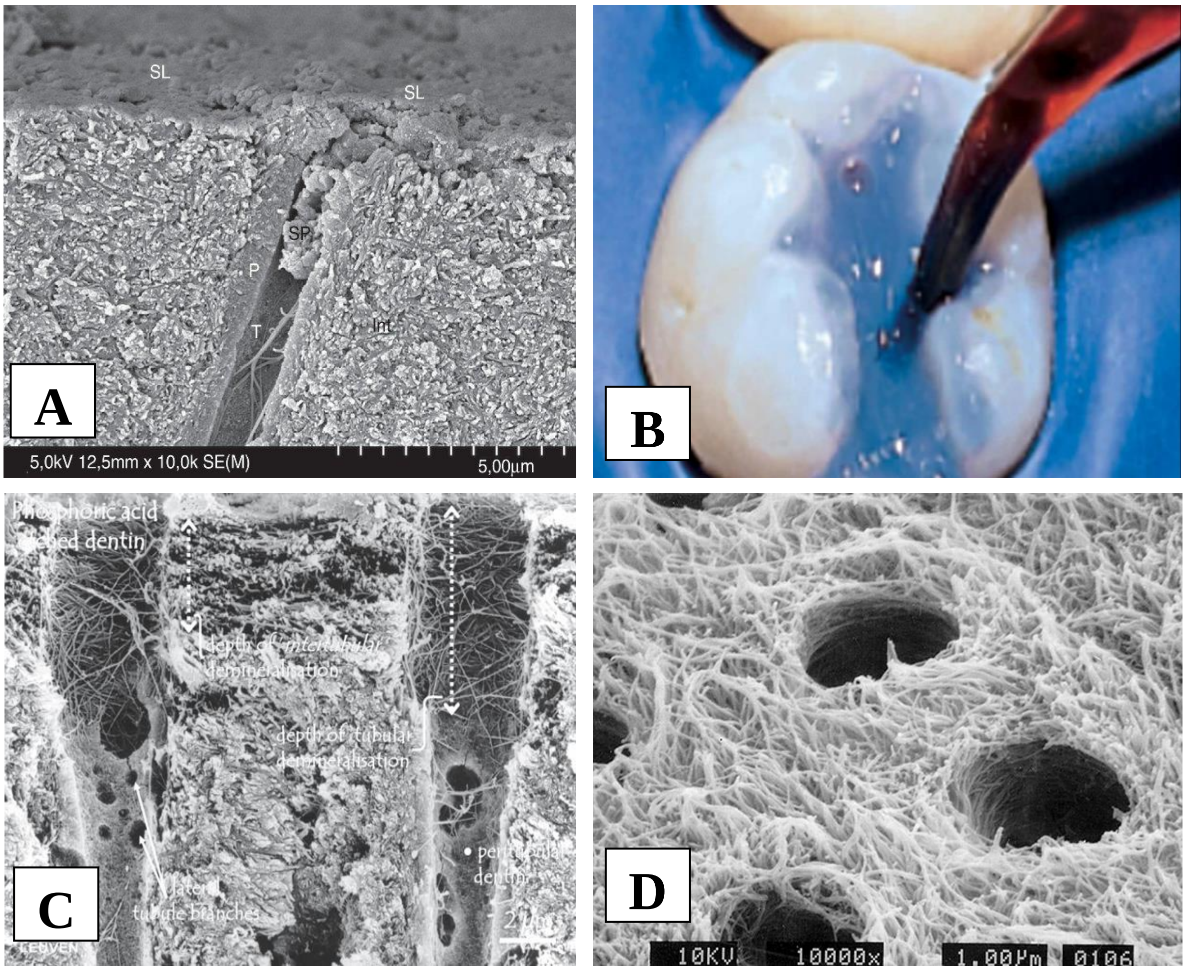
3. **Adhesive:** The adhesive resin is a low viscosity, filled or unfilled resin which flows easily and matches the composite resin. Adhesive combines with the monomers to form a resin reinforced hybrid layer and resin tags to seal the dentin tubules.

Etching of dentin results in removal of smear layer and minerals from dentin structure, exposing the collagen fibers. 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.

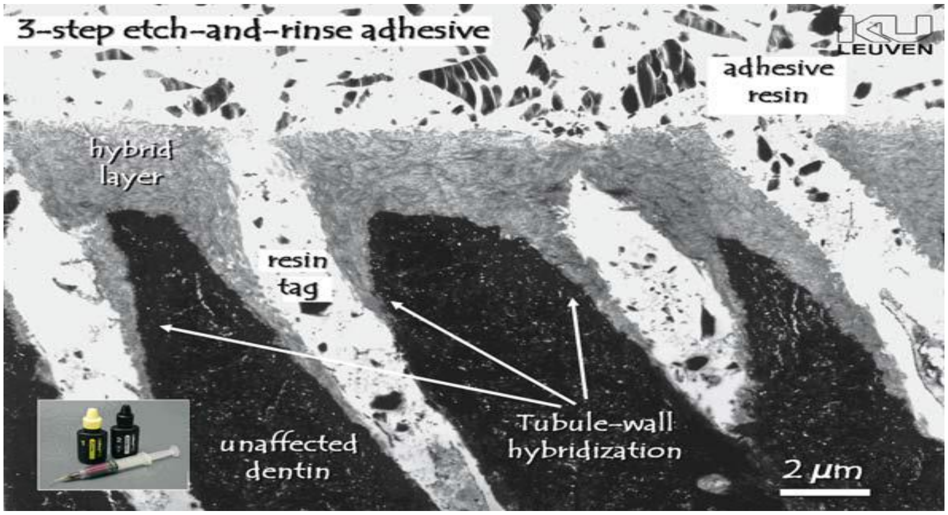
If the dentin surface is made too dry, there will be collapse of the collagen fibers of demineralized dentin. This results in low bond strength because of ineffective penetration of the adhesive into the dentin.

Primers are used to increase the diffusion of resin into moist and demineralized dentin and thus optimal micromechanical bonding. For optimal penetration of primer into demineralized dentin, it should be applied in multiple coats.

Total etch technique involves the complete removal of the smear layer by simultaneous acid etching of enamel and dentin. After total etching, primer and adhesive resin are applied separately or together.



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



Dentin bonding with 4th generation dentin bonding agents (etch and rinse technique)

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 Dentin Bonding Agents

Fifth-generation DBAs were made available in the mid-1990s. Similar to the fourth generation, they are based on the total etch technique (a separate step of acid etching is needed). They are also known as "one-bottle" or "one-component" bonding agents. 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.
Fourth generation bonding system is available in two bottles, one primer and other adhesive, fifth generation dentin bonding agents are available in one bottle only.

Sixth Generation Dentin Bonding Agents

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

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

Advantages

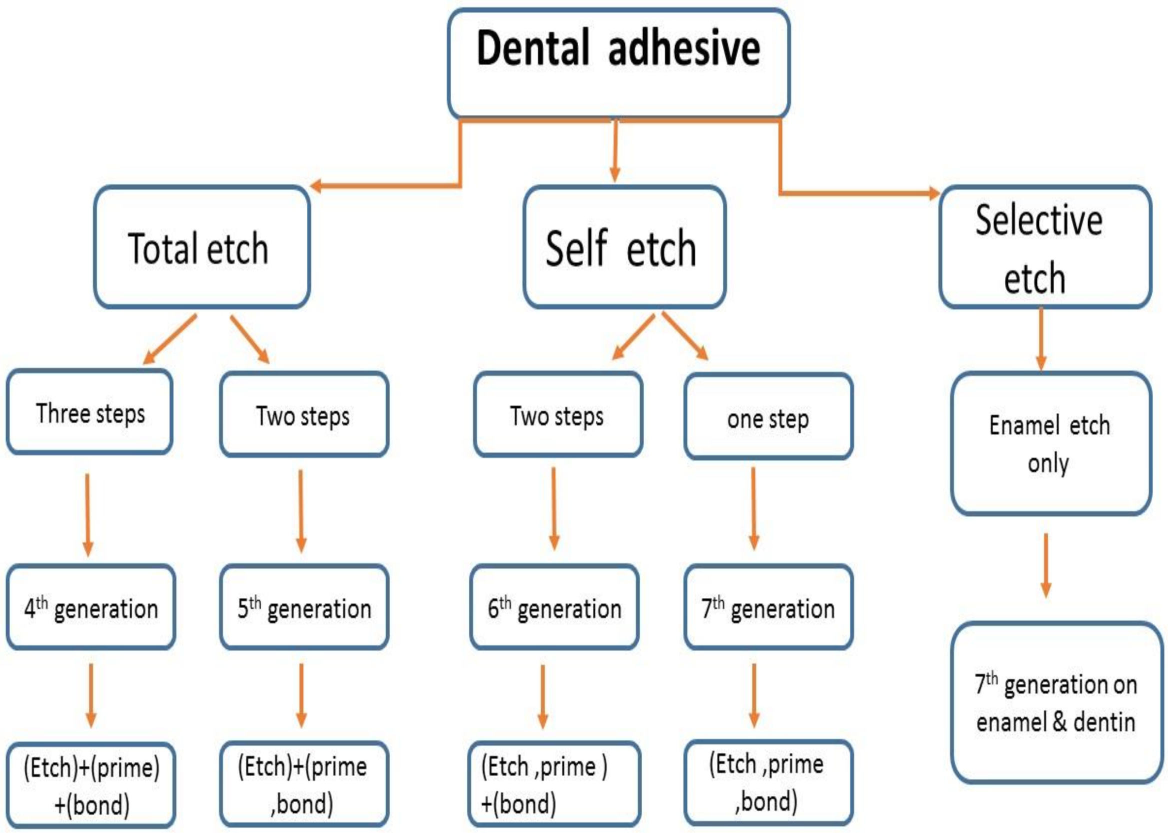
- Reduces postoperative sensitivity because they etch and prime simultaneously.
- It etches the dentin less aggressively than total etch products.
- Demineralized dentin is infiltrated by resin during the etching process.
- Since they do not remove the smear layer, the tubules remain sealed, resulting 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 fewe number of steps are involved for the self-etch system.

Seventh Generation Dentin Bonding Agents

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).

8th generation

The term universal is being used in three main ways. One refers to the capability of these adhesives to adhere by different application methods, namely self-etch, total etch or selective enamel etch. Another is the capability to be used with all light, dual and self-cure materials. The last is the ability to adhere to all common dental substrates including direct and indirect restorations and repairs



OPERATIVE DENTISTRY

Lecture (11)

Management of Deep Seated Caries

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.

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

I-Protective Base:

A protective base 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 protective base such as calcium hydroxide and glass ionomer cement is at the dentist's discretion.

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 base may be placed between the permanent restoration and the dentin to minimize pulp injury, promote pulp tissue healing, or minimize postoperative sensitivity.

Objectives: A protective base 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

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 demineralized dentine could be left behind in deep cavities of the tooth before restoration, often with highly satisfactory results. This is especially applicable if micro-exposures of the pulp are suspected. The removal of this dentine may lead to exposure of the pulp, thus impairing its prognosis.

It has been shown that demineralized dentine, if it is free of bacteria, will remineralize once the source of the infection has been eliminated. The diagnosis of the presence of demineralized dentin that is caries-free can be assisted by using a caries disclosing solution. The placement of a suitable material directly on this demineralized dentin is commonly called indirect pulp capping (IPC).

IPC has been defined as the steps undertaken to protect a vital tooth where removal of all affected tissues would result in a pulpal exposure.

In this context a non-exposed pulp is one that exhibits no signs of haemorrhage at or near the pulp chamber. When carrying out such a procedure it is vitally important that the infection is removed and is not allowed to recur.

Material used for IPC

1) This can be achieved with the placement of an antibacterial liner such as calcium hydroxide 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 cement followed by an adhesive liner 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 (1PC):

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 4 - 6 W or more Cement removed.

7. Internal surface of the cavity inspected for remineralization and hard dentin (2nd 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 noncarious exposures during cavity preparation.
2. Pulp capping should be considered only for immature permanent teeth.
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 vital pulp therapy

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

(1) The pulp is not inflamed;

(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.

A major disadvantage of calcium hydroxide materials

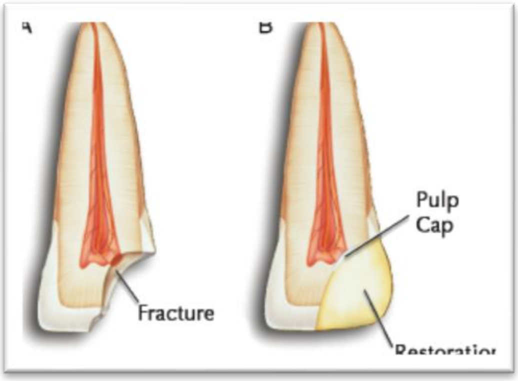
1. They do not seal the exposed pulp from the external environment. Therefore, an additional base material, such as a resin-modified glass ionomer, can be placed to help seal the pulp against bacterial ingress during the healing phase.
2. Dentin bridges beneath calcium hydroxide pulp caps contain 'tunnel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

Therefore, various other materials, including zinc oxide eugenol, glass ionomers, resin adhesives, and mineral trioxide aggregate (MTA), have been proposed as capping agents for vital pulp therapy. MTA is an alkaline material that stimulates dentinal bridging and appears to have particular promise as a pulp-capping material.

(4) The bacteria seal out base and restoration.

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 to 6 weeks for final resoration.

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 necrosis 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 s 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.

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.

If the pulp is large enough to allow an additional 1– 2mm loss of tissue through necrosis, 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.

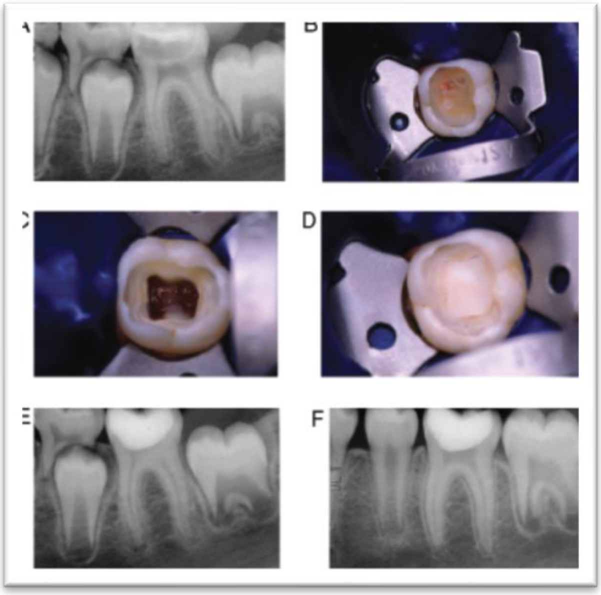
V- Full pulpotomy

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, but as much as 2–3mm apical to the 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.

ENDODONTICS

Lect:11 Ass. Lec. Othman H. Alani

Obturation Techniques

Different methods are available for obturating root canal system. This lecture: will focused on the following

1. Lateral compactioh technique.

2. Vertical compaction technique.

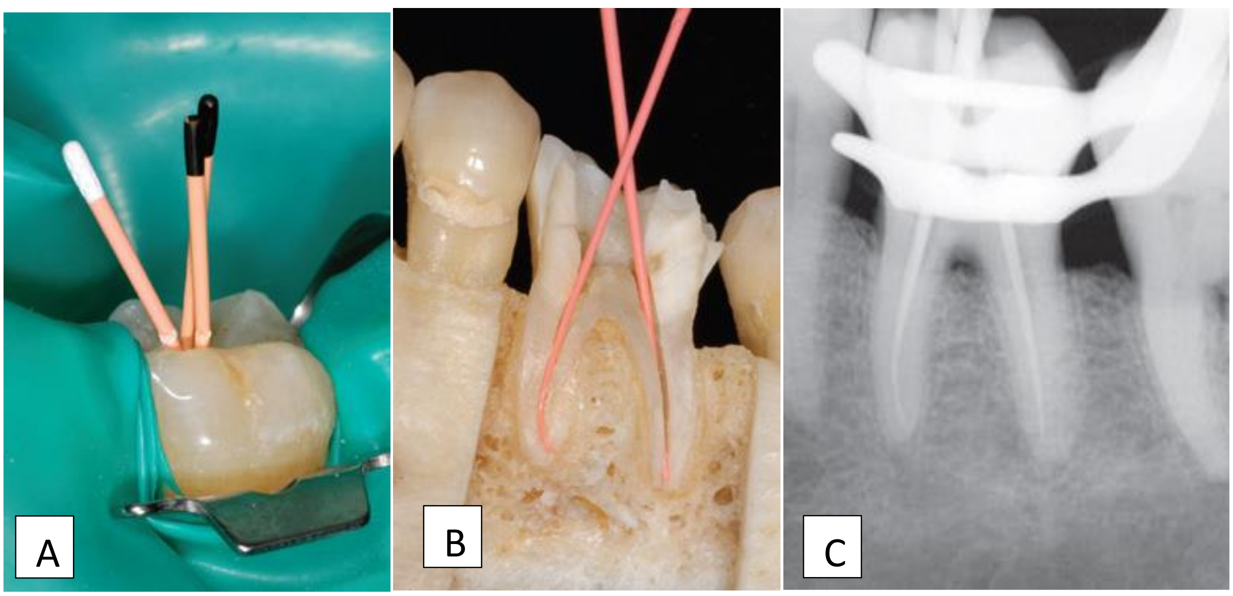
Armamentarium for obturation:

- Primary and auxiliary (accessory) cones of gutta percha.
- Absorbent paper point for dryness of the root canal after irrigation complete. These point are available with different sizes and tapering matching that of gutta percha cones.
- Spreaders and pluggers for compaction of gutta percha. These instrument also available in different sizes to tit the size of the prepared canal. The spreaders are either hand or finger spreaders with pointed tips and sizes starting from ISO size 20 to 45 or 50. The pluggers are mainly available with handles and flat tips to vertically compact the soften gutta percha. The tip sizes are available from 0.4 to 1.2mm.
- Endodontic ruler for measuring the length of gutta percha point.
- Scissor for cutting gutta percha points during fitting inside the canal.
- Heating device such as spirit lamp or gas torch.
- Heating instrument such as spoon excavator.

Lateral compaction technique:

The most common obturation compaction technique involves the placement of the master gutta percha point and accessories under lateral pressure against the canal walls by using a spreader. The canal should be continuously tapered shape with definitive apical stop. The procedure is as follow:

1-After canal preparation, select the master gutta-percha cone, whose size is consistent to the size of the largest file used in instrumentation up to the full working length. This gutta-percha cone is called **master apical cone (MAC)**. This cone have to fit to the full WL of the canal (Fig-1: A).



(Fig -1: A, B&C)

a-Should feel resistance when you pull the cone out of the canal. This resistance comes from the engagement of MAC between walls of the apical region of the prepared canal (3-5mm of the apical canal region). This feeling of resistance is called **tug back** (Fig-1: B). If the MAC fit the entire WL but no tug back, you can either choose larger cone size or cut 0.5 - 1mm from the cone tip until a tug back has to be fit. After that mark the WL on the MAC at the level of incisal or occlusal reference point. This can be done by making a notch on the MAC at this level (Fig-1: A).

b- Check the fit of MAF radiographically (Fig-1: C).

- If the master cone fit within canal WL, remove the cone from the canal and place it over a piece of cotton socked in either sodium hypochlorite or 96% ethanol.
- If the MAC fits shorter of the WL, check for any canal blocking by dentin chips, ledge or canal curvature and treat them accordingly.
- If the MAC going beyond the apical foramen, either select larger cone size or cut the cone to the WL.
- If the tip of MAC shows “8" shape in radiograph this means that the cone is too small for the canal. A larger size can be selected to fit the canal.

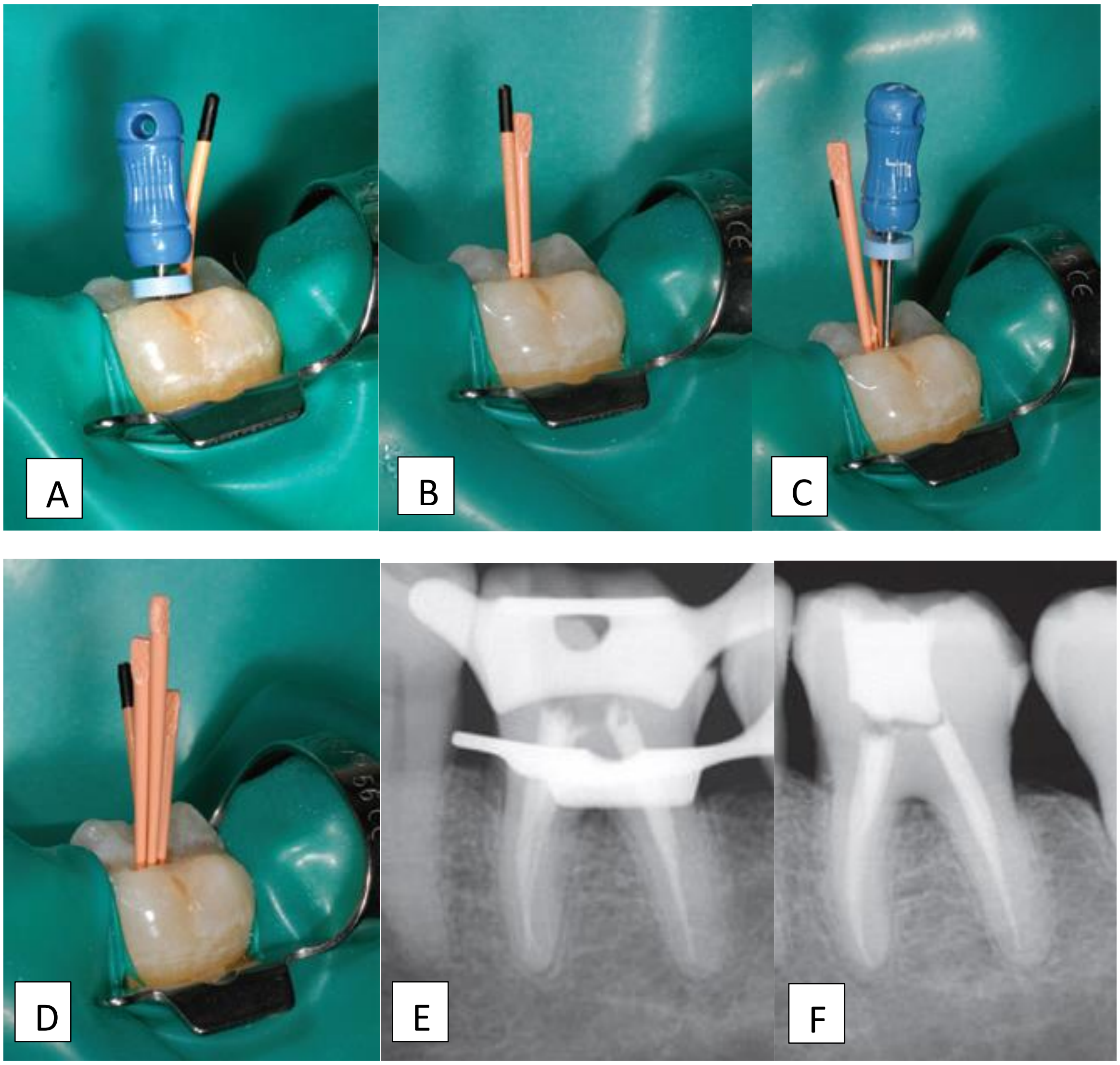
<u>2-</u>Select suitable size of a spreader to be used for lateral compaction, which should reach 1-2mm shorter of the canal WL.

<u>3-</u>Dry the canal completely with paper point.

<u>4-</u>Mix the sealer according to the manufacturer instruction and apply it within the canal either by a paper point or a clean file with counter clockwise rotation inside the canal .

<u>5-</u>Coat the measured MAC with small amount of sealer and place it inside the canal. The spreader then placed into the canal alongside the MAC with vertical gentle pressure. The spreader will act as a wedge to compact gutta percha laterally under vertical pressure on the wall of the canal (Fig 2: A)

After that the spreader can be removed from the canal by rotating it back. This will leave a space alongside the MAC for the accessory gutta percha.



(Fig .2: A, B,C,D,E&F)

An accessory cone can then be placed into the left space (Fig 2 :B) and the above procedure is repeated until the spreader can no longer penetrate beyond the cervical line (Fig 2: C&D).

Finally the cut the protruded parts of gutta percha points with hot instrument such as spoon excavator of the endo plugger (Fig 2 :E). A gentle vertical compaction can also be done by the plugger to seal the coronal orifice of the canal with the melted gutta percha (Fig 2: F).

Advantages of lateral compaction:

1-It can be used with the most routine clinical situations.

2-During lateral compaction, it provides length control with less chance of overfilling and post-operative pain.

Disadvantages:

1-May not sufficiently fill the irregularities within the canal.

2-Does not produce homogenous mass.

3-Voids and spaces may exist between accessory and master cones.

Vertical compaction technique:

This technique was introduced to overcome the drawbacks of lateral compaction technique. It uses hot plugger with vertical pressure to compact the heat soften gutta percha to flow into canal irregularities. The prepared canal that can be filled by this technique should have:

- A funnel shape with continuous tapering to the apex.
- Good apical stop region (apical constriction is as small as possible).

The procedure is as follow:

- ❖ Select the master cone gutta percha which should fit the canal size and taper, and check its fitness by radiograph.
- ❖ Dry the canal completely with paper point.
- ❖ Select the sizes of pluggers according to the size and taper of the canal. Pluggers should be pre-fitted at 5 mm intervals in order to capture maximum cross section area of the softened gutta percha.
- ❖ Coat the canal lightly with sealer by a paper point.
- ❖ Cut the coronal end of the gutta percha cone at the incisal or occlusal reference point.

- ❖ Use the heated plugger to vertically force the master cone into the canal. Fold the soften gutta-percha inward to fit apically and laterally. If the soften gutta percha stuck into the plugger tip, just slight rotate the plugger to loosen it. This vertical compaction will free 2-3 mm of space coronally to allow adding more gutta-percha.
- ❖ After finish the apical filling, complete obturation by doing backfilling. This can be done by heating small segment of gutta perch and carrying them into the canal using heated larger pluggers.
  - ✓ Be careful not to overheat the gutta-percha to facilitate its handling.
  - ✓ Don't apply more sealer into the soften gutta-percha because this will prevent the adhesion between the soften layers of gutta-percha.

- ❖ After completion, clean the pulp chamber from the excess of sealer and gutta-percha by a piece of cotton socked in alcohol then put the temporary or final restoration.

Advantages of the vertical compaction technique:

Provide excellent sealing of the canal apically and laterally with filling of the lateral and accessory canals.

Disadvantages

1- Increase the risk of vertical root fracture.
2- 2-Overfllling and apical extrusion of the gutta-percha and sealer periapically.
3- Time consuming procedure.

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Operative Dentistry

CAD/CAM Techniques

Computer-aided design (CAD) and computer-aided manufacturing (CAM) are digital technologies used to design, plan and ultimately create dental prosthodontics with 3D printing technology. With CAD/CAM, dentists can efficiently create dental crowns, teeth bridges, veneers, onlays, inlays, dentures, and dental implant-supported prostheses.. CAD/CAM in dentistry has resulted in more efficient, cost-effective, and accurate processes for creating restorations.

Components of CAD/CAM dental technology

Various tools and technology are used in CAD/CAM dentistry:

- **Scanner:** Also called a digitalization tool, the scanner scans and transforms the images of your teeth into the computer to be processed.
- **CAD software:** This is used to process the images of your teeth and plan your custom dental prostheses. This software can also show you your predicted treatment results.
- **CAM machine:** This machine transforms your dental scans into the actual restoration via 3D printing.

Below for a summary of the differences between CAD/CAM and traditional restorations:

Material	Ceramic/resin	Ceramic/resin
Number of appointments	Multiple	Single appointment
Aesthetics	Good results	Most accurate
Teeth preparation	Lots of prep required for cement and temporization	More conservative and precise preparation
Dental impressions	Manual via plastic/metal trays and impressions	Digital scanning only
Price	Cheaper	More expensive

Advantages of CAD/CAM
Faster treatment time
Easier treatment
Convenient for patient
More comfortable processes for patient
More precise
Best aesthetics

Disadvantages of CAD/CAM
More expensive
Extra training required
Some patients may not like the opacity of the restoration.

Setps of CAD/CAM

1.Computer surface digitization
Scanning of prepared tooth is done either with LED based or Laser based scanners .

*LED based scanner: A small hand held video camera with a 1cm wide lens (scanner) when placed over the occlusal surface of the prepared tooth, emits infrared light which passes through an internal grid containing a series of parallel lines.

*Laser based scanner: A high speed laser takes digital scans of the preparation and proximal teeth to create an interactive 3D image.

2. Computer-aided designing (CAD)
A three-dimensional image of the die is produced over the screen and can be rotated for observation from any angle. Once the 3-D image is captured through any of the computer surface digitization techniques, 3-D image processing is done and the digitized data is entered in the computer . Finally, curve smoothening data reduction and blocking of undercuts can be done at this stage. Designing of the restoration is done using CAD software, which in turn sends commands to the CAM unit, for fabricating the restoration.

3.Computer-aided manufacturing (CAM)

Third and the final stage is Computer-aided manufacturing (CAM). The CAM technologies can be divided in three groups according to the technique used :
a. Subtractive technique from a Solid Block: In this stage the milling is done with computerized electrically driven diamond disks or burs which cut the restoration

from ingots. The CAM technique most commonly applied in manufacturing frameworks for single crowns and the size of the material blocks available for the milling units limits the size of the FPDs .

b. Additive technique (by applying Material on Die): Here in this technique Alumina or Zirconia is dry pressed on the die and the temperature is raised to a temperature similar to the pre sintering state. At this stage, enlarged and porous coping is stable. Its outer surface are milled to the desired shape and coping, removed from die, and sintered into the furnace for firing to full sintering .

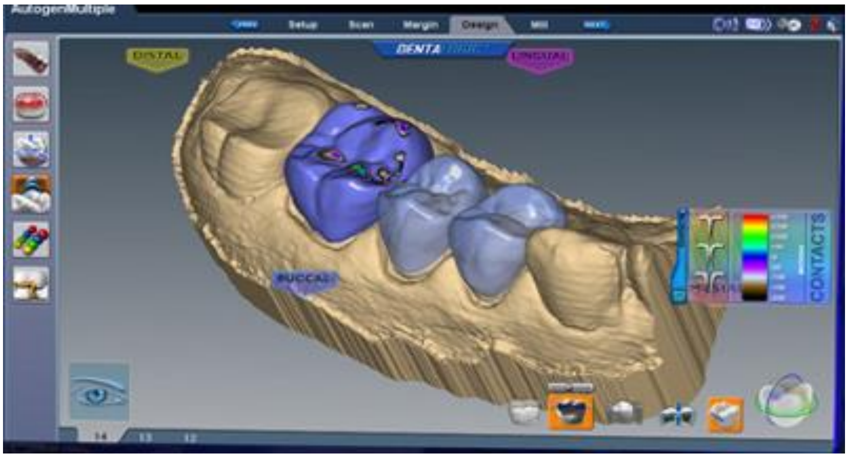


Figure (1) **Computer-aided designing (CAD)**

Figure (2):milling

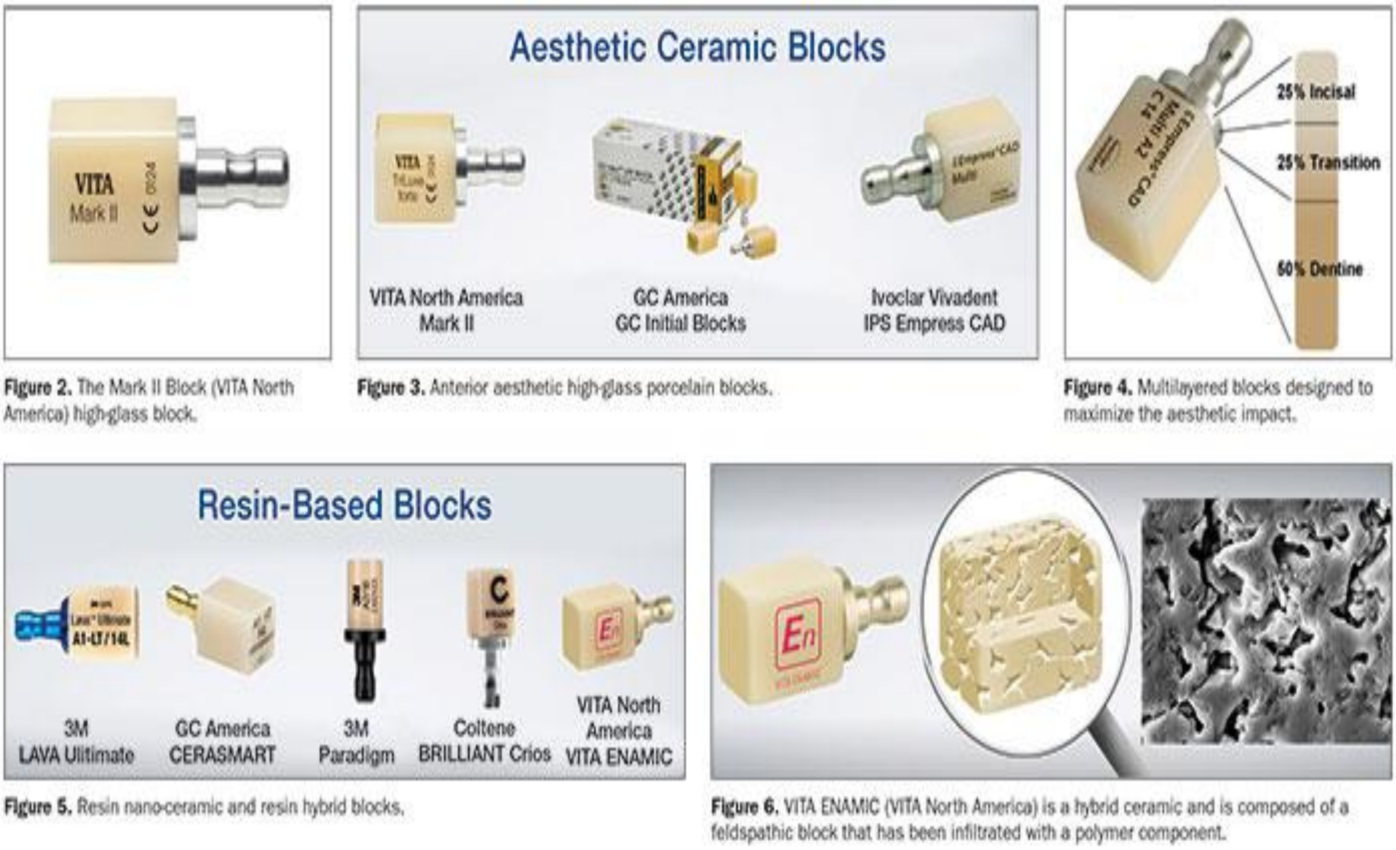


Figure (3): CAD/CAM materials

General Classification Of CAD/CAM Systems:

Based on their production methods systems have been divided into the following :

1. In office system:

Most widely used is Cerec System. Intraorally scanning of the preparation and selection of appropriate materials is done by this system due to which the restorations can be fabricated and seated within a single appointment .

2. CAD/CAM- Dental laboratory systems:

The indirect systems scan a stone cast or die of the prepared tooth, in the dental lab (eg Cerec-in lab). Many of these systems produce copings after which the dental technician adds esthetic porcelain to the restoration.

Most Common CAD/CAM Systems:

Cercon:
It does not have a CAD component. In this system, a wax pattern (coping and pontic) with a minimum thickness of 0.4 mm is made. The system scans the wax pattern and mills a zirconia bridge coping from presintered zirconia blanks. The coping is then sintered in the Cercon heat furnace (1,350C) for 6 to 8 hours .

Everest:
The Everest system consists of scan, engine, and therm components. In the scanning unit, gypsum cast is fixed to the turntable and scanned by a camera .Its machining unit has 5-axis movement that is capable of producing detailed morphology and precise margins from a variety of materials. Examples: leucite reinforced glass ceramics, partially and fully sintered zirconia, and titanium.

Lava:
This system uses yttria stabilized tetragonal zirconia poly crystals (Y-TZP) which have greater fracture resistance than conventional ceramics.Lava system uses a laser optical system to digitize The Lava CAD software automatically finds the margin and suggests a pontic. The framework is designed to be 20% larger to compensate for sintering shrinkage.

Procera:
This system has combined pantographic reproduction with electrical discharge (spark erosion) machining. It uses an innovative concept for generating its alumina and zirconia copings .
First, a scanning stylus acquires 3D images of the master dies that are sent to the processing center via modem. The processing center then generates enlarged dies designed to compensate for the shrinkage of the ceramic material. Copings are manufactured by dry pressing high-purity alumina powder (> 99.9%) against the enlarged dies. These densely packed copings are then milled to the desired thickness. The Procera restorations have excellent clinical longevity and strength .

DCS Precident:
It is comprised of a Preciscan laser scanner and Precimill CAM multitool milling center. It can scan 14 dies simultaneously and mill up to 30 framework units in 1 fully automated operation . Materials used: Porcelain, Glass Ceramic, In- Ceram, Dense Zirconia, metals, and Fiber- Reinforced Composites. This system is one of the few CAD/CAM systems that can mill titaniumand fully dense sintered zirconia .

CICERO System:
The computer integrated crown reconstruction was developed by CICERO Dental System B.V. (Hoorn, The Netherlands). The CICERO method for production of ceramic restorations uses official scanning, ceramic sintering, and computer assisted milling techniques to fabricate restorations with maximal static and dynamic occlusal contact relations. The system makes use of optical scanning, near net-shaped metal, ceramic sintering and computer-aided fabrication techniques .

CEREC SYSTEM: The computer- aided design/computer-aided manufacture (CAD/CAM) CEREC (computer-assisted CERamic REConstruction) system is used for electronically designing and milling restorations.

E4D Dentist System:
Presently it is the only system besides CEREC that permits same day in-office restorations. This system includes a laser scanner (Intraoral digitizer), a design center and a milling unit. The scanner is placed near the target tooth, and has 2 rubber feet that hold it to specific distance from the area being scanned. As each picture is taken, the software gradually creates a 3D image. The design system automatically detects the finish lines and marks them on the screen. As soon as the restoration is approved, the data are transmitted to either the in-house milling machine or a dental laboratory. The office milling machine will then manufacture the restoration from the chosen blocks of ceramic or composite.

Operative Dentistry

Cervical Lesions (Carious and non Carious)

Class 5 lesions are carious and noncarious defects found in the gingival third of facial and lingual tooth surfaces. Class 5 caries lesions are produced by bacterial plaque attaching to the surface of teeth and producing acids that cause demineralization. A Class 5 lesion resulting from factors other than dental caries is known as a **noncarious cervical lesion**

Caries Lesions

Root caries lesion is “a soft, irregularly shaped lesion either totally confined to the root surface or involving the undermining of enamel at the cementoenamel junction, but clinically indicating that the lesion initiated on the root surface. A root caries lesion can be initiated only if the root surface is first exposed to the oral environment. 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 esthetic 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. The best correlation to date for clinical detection of caries lesions on root surfaces is the softness of the surface as evaluated with a dental instrument.

Diagnosis

Although clinicians detect root caries lesions by judging changes in color (yellow, brown, black), texture (soft, hard), and surface contour (regular, irregular), examination strategies should focus on patients at risk for root caries. Therefore, the first step in the diagnosis of root caries is early identification of contributory factors and oral hygiene practices. Because plaque and debris often severely limit the visibility of root surfaces, a thorough dental prophylaxis should precede any clinical examination of patients at risk for root caries. Gentle tissue displacement with an air syringe and retraction with hand instruments can offer a better view of subgingival and interproximal areas, while the use of transillumination and intraoral cameras can also enhance visibility and improve diagnostic capability.

Restorative Treatment

When root caries lesion has progressed such that restoration of lost structure is necessary, the dentist faces difficulties that differ considerably from those posed by many coronal lesions. The challenges to the restorative dentist include impaired visibility, difficult access, moisture control, pulpal proximity, and the nature of the dentinal substrate itself. These factors tend to compromise the ideal restoration, which should conserve remaining tooth structure and provide long-term integrity of marginal seal. There is general agreement today that, when possible, adhesive fluoride-releasing restorative materials are preferred. Isolation is the key to long-term success in root surface restorations.

Noncarious Cervical Lesions NCCL(s)

Etiology

The entire etiology of NCCLs has not been determined. While the various possible causes and their degree of involvement may be controversial, there is overwhelming evidence that the cause is multifactorial. A review of the literature shows disparate opinions as to the primary cause, with nearly equal evidence to support toothpaste/toothbrush abrasionocclusal forces, and low pH. Thus, it is likely that varying combinations of stress factors contribute to the initial lesion and further loss of tooth structure. ***Erosion***, the loss of tooth structure from chemical dissolution; ***abrasion***, the loss of tooth structure by mechanical or frictional forces; and ***abfraction*** or stress corrosion, the loss of cervical tooth structure due to occlusal forces have all been implicated in the formation of some NCCLs. Patients should be informed of the possible etiologies, implications of the presence of lesions, prevention methods, treatment alternatives, and expected outcomes. Failure to appropriately prevent and treat NCCLs can result in (1) progressive loss of tooth structure, (2) tooth sensitivity, (3) the need for endodontic therapy, (4) tooth loss, and (5) the occurrence of additional lesions.

Caries lesions and noncarious lesions are more common on facial surfaces of teeth than on lingual surfaces. While toothbrush/toothpaste force is a significant etiologic factor, an additional consideration could be differences in the chemistry and character of saliva in lingual and facial areas, which bring about differences in remineralization of tooth structure and the dilution and buffering of acids.

Toothbrush abrasion

When a tooth is softened by acid dissolution, the effects of any mechanical wear are greatly accelerated. The effect of the acid on enamel and dentin makes the tooth more susceptible to abrasion and attrition (occlusal wear).

Erosion

- Dental erosion is a chemical process characterized by acid dissolution of dental hard tissue not involving acids of bacterial origin.
- Erosive demineralization can result in progressive, irreversible loss of tooth mineral substance, and may be caused by intrinsic (e.g., acid reflux and excessive vomiting) and/or extrinsic (e.g., dietary) factors.
- Frequent consumption of soft drinks, particularly carbonated sodas, is a primary risk factor for erosive tooth wear. Consumption of acidic snacks/sweets or natural acidic fruit juice may also increase risk for erosion.
- Diagnosis and management of dental erosion includes careful clinical examination and evaluation of the patient to identify common signs of erosion (e.g., loss of enamel texture, cupping or flattening on occlusal surfaces), predisposing factors for erosive tooth wear, and options to reduce probability of exposure to erosive (acidic) drinks, dietary sources and/or other acids of intrinsic or extrinsic origin.


Abrasion

- Abrasion is the wearing away of tooth surface caused by friction or a mechanical process.
- Abrasion happens when teeth are brushed too vigorously in sweeping horizontal strokes. The use of a hard toothbrush can also cause the problem
- It is often evident on the outer surfaces of the back teeth. A wedge or V-shaped indentation of the tooth will be seen at the gum margin.
- Toothbrush abrasion can be repaired by bonding a tooth-colored filling over the abraded area of the tooth.

Abfraction

It has been proposed that occlusal loading causes deformation and flexure of the tooth, resulting in disruption of the enamel crystals at the cervical region and thereby contributing to the formation of an NCCL,

Abfraction is the loss of tooth structure from flexural forces. it is hypothesized that enamel, especially at the cementoenamel junction (CEJ), undergo this pattern of destruction by separating the enamel rods.

Treatment approaches

Before any treatment is performed for a patient with one or more NCCLs, a careful examination and determination of possible causes for the lesions should be made. The first goal of any treatment is to remove the causes of the NCCL(s). Once the etiologic factors for a patient are determined, the dentist can help the patient to understand them and to change those that are under his or her control. If a patient is experiencing acute sensitivity associated with one or more lesions, treatment to alleviate the sensitivity should be accomplished. This treatment could involve desensitizing the tooth, restoring the tooth, or possibly performing a periodontal procedure, such as a connective tissue graft, to cover and protect the affected area.

Because of the location of Class 5 lesions, access for restorative treatment is often troublesome, moisture control can be exceedingly difficult to obtain and maintain, and soft tissue surgical approaches may be required. Because of the sclerotic nature of the tooth structure in a cervical lesion and the physical properties of restorative materials, long-term retention of the restoration presents a unique challenge.

Shallow lesions that lead to thermal sensitivity or sensitivity to touch should first be treated with bonding resins or desensitizing agents.
The decision to place a restoration because of a Class 5 lesion is not always easily made. Certainly, if active caries is present, treatment should be initiated to control the active disease and to prevent disease progression. Treatment decisions relating to NCCLs or arrested caries lesions, however, are more difficult. It is generally believed that NCCLs should be treated to protect remaining tooth structure if the amount of tooth structure lost is extensive or progressing, if esthetics is compromised, or to control sensitivity not relieved by less invasive procedures.

The recommendations to restore a tooth affected with a NCCL should depend upon the following factors:

- Inability to eliminate or greatly reduce the rate of lesion progression through elimination of etiologic factors
- Esthetic unacceptability of the lesion to the patient
- Significant sensitivity of exposed dentin to cold liquids, food, and air
- Threat to the strength of the tooth and integrity of the coronal-radicular unit because of the lesion's depth.

Fluoride-Releasing Materials

Fluoride plays several significant roles in any caries-prevention program. These include the formation of fluorapatite (by replacing the ions lost during demineralization with fluoride) which is more acid resistant, larger and stronger crystal than hydroxyapatite, the enhancement of remineralization, interference with ionic bonding during pellicle and plaque formation, and the inhibition of microbial growth and metabolism.

Flouride Varnishes

Fluoride varnishes and gels are available and are successful in preventing caries. Varnishes provide a high uptake of the fluoride ion into the enamel, yet provide a lower dosage of fluoride than gels or rinses. These are professionally applied, yet may provide the most cost-effective means of delivery of fluoride to the teeth. They are effective bacterio- cidal and caries prevention agents.

Glass Ionomors

Glass ionomers are materials comprised of a polyalkenoic acid polymer matrix and ion leachable fluoroaluminosilicate glass filler particles. Carboxylic acid chains on the polyalkenoic acid form ionic bonds with calcium and aluminum ions leached from the glass filler. The earliest glass-ionomer materials for restorations were 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) dissolves portions of the periphery of the silicate glass particle, releasing calcium, aluminum, fluoride, silicon, and other ions. Divalent calcium ions are quickly chelated by ionized carboxyl side groups on polyacrylic acid polymer chains, cross-linking the chains and producing an amorphous polymer gel. During the next 24 to 72 hours, the calcium ions are replaced by more slowly reacting aluminum ions to produce a more highly cross-linked matrix that is now mechanically stronger.

The same carboxylic acid side groups also are capable of chelating surface ions on the glass particles, or calcium ions from the tooth structure. This process generates true chemical bonds at all internal and external interfaces when the reaction conditions are correct. Set materials have modest properties compared with composites, but have relatively good adhesion and the ability to release fluoride ions from the matrix for incorporation into the neighboring tooth structure to suppress caries.

The following list summarizes the characteristics of traditional glass-ionomer materials:

Advantages

- Form a rigid substance on setting
- Good fluoride release (bacteriostatic, inhibit caries)
- Low exothermic reaction on setting
- Less shrinkage than polymerizing resins
- Coefficient of thermal expansion similar to dentin
- No free monomers
- Dimensional stability at high humidity
- Filler–matrix chemical bonding
- Resistant to microleakage
- Non-irritating to pulp
- Good marginal integrity
- Adhere chemically to enamel and dentin in the presence of moisture
- Rechargeable fluoride component
- Good bonding to enamel and dentin
- High compressive strength

Disadvantages

- Susceptible to dehydration over lifetime
- Sensitivity to moisture at placement
- Poor abrasion resistance
- Average esthetics
- Less tensile strength than composites
- Technique sensitive powder-to-liquid ratio and mixing
- Less color-stable than resins
- Contraindicated for Class IV or other stress-bearing restorations
- Poor acid resistance

Resin-modified glass-ionomer cement

RMGIs contain elements of conventional glass ionomers and light-cured resins but have properties most similar to conventional glass ionomers. The matrix consists of polyalkenoic acids modified with unsaturated carbon bonds and/or mixed with (di)methacrylate monomer(s), allowing these materials to cure through acid-base‑initiated ionic bonding and polymerization through free radical‑initiated covalent bonding (Two separate setting reactions occur: one common to conventional glass ionomers and the other common to photoinitiated resin composites). The photoactivation may affect the material's final properties, depending on the strength of the glass-ionomer cure.

In general, the RMGICs appear to perform well in terms of retention. Secondary caries, as well as postoperative sensitivity, are not a problem. However; RMGIs, like conventional glass ionomers, should not be used for restorations in occlusal load‑bearing areas in the permanent dentition where heavy occlusal forces are present.

- RMGICs found that the marginal adaptation was poor at 18 months and likely to deteriorate over time.
- From the limited data that the RMGICs exhibit some loss of anatomic form and surface wear, particularly in the mid to long term.
- While the initial color match may have been favorable relative to tooth structure, it appears that these materials change over time. This may be related to the surface changes within the materials as manifested in the form of loss of anatomic contour and wear
- The RMGICs cannot be considered biocompatible to the same extent as conventional glass-ionomers.

Resin composites

Fluoride can be incorporated into resin composites through three mechanisms: *(1)* adding fluoride compounds such as sodium fluoride (NaF) or stannous fluoride (SnF_2) *(2)* incorporating fluoride-releasing fillers; or *(3)* integrating fluoride into the resin matrix. Fluoride-releasing resin composites have superior mechanical properties, no inherent adhesive properties (they need a bonding agent to adhere to tooth structure), and better wear resistance compared with other materials .However, they also have the lowest fluoride release and are least capable of being recharged

Compomers (Polyacid-modified resin composites)

Polyacid-modified resin composites, which are more widely known by the name "compomers," attempt to combine the best properties of glass ionomers and composite resins. A major reason for their success is that they are user-friendly: they are soft, nonstick, do not need to be mixed, and are easy to place. They are easy to inject into a cavity, simple to shape, quick to cure, and readily polished after curing. They are used in anterior proximal restorations and in cervical restorations. In almost all other areas, composites and glass ionomers are preferred.

Compomers require a dentin bonding system and acid etching of tooth structure to achieve a clinically acceptable bond. These materials release more fluoride than resin composites but less than conventional glass ionomers or RMGIs, and the small amount they do release may be of limited value since the resin bonded interface prevents the fluoride from entering the tooth. Their abrasion resistance is intermediate between RMGIs and resin composites.

The advantages of compomers include the following characteristics:

• No mixing required
• Easy to place
• Easy to polish
• Good esthetics
• Excellent handling
• Less susceptible to dehydration
• Radiopaque
• Higher bond strengths than resin-modified glass ionomers
• Stronger than glass ionomers

The disadvantages of compomers include the following characteristics:

• Bonding agent required
• More leakage than resin-modified glass ionomers
• Expand from water sorption over time
• Wear more easily than composites
• Longevity difficult to predict because of an enormous variety of products
• Physical properties weaker than those of composites, and they decrease over time
• Limited fluoride uptake.

Giomers

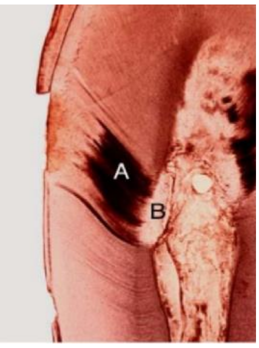
A new class of material has been introduced to the market that is termed *giomer* (glass-ionomer and polymer). Giomers use prereacted glass-ionomer (PRG) technology to form a stable phase of glass-ionomer fillers in a resin matrix. The PRG filler is made by reacting fluoride-containing glass with polyalkenoic acid in water. The PRG filler is then freeze-dried, milled to a desired size, silanized, and added to the resin matrix.

The advantage of giomers is the enhanced availability and accessibility of the fluoride within the PRG fillers compared with that in resin based materials (such as compomers and certain resin composites). Giomer materials have fluoride recharge, biocompatibility, a smooth surface finish, excellent esthetics, and clinical durability, which have made them popular for restoration of root caries, noncarious cervical lesions, Class 5 cavities, and lesions in primary teeth.

Defense Mechanisms of the Pulp and Dentin against Injury

The reaction of the pulp and dentin to injury is mainly related to the activity of the odontoblast cells. A variety of reactions to injury could be seen which include:

1. Dead Tracts



These are regions of empty tubules in primary dentin that result from degeneration of the odontoblastic process found under most carious cavities.

At the proximal end of the tubules (near the pulp), the dead tract has been sealed off by a layer of impermeable calcified tissue protecting the pulp.

2. Sclerotic Dentin

This type of dentin result from either aging or mild irritation (such as slowly advancing caries) and causes a change in the composition of the dentin. The peritubular dentin become wider and thicker as the tubules being filled and obliterated with calcifying minerals. Continued intratubular mineralization of dentin may result in complete obturation of the tubules. These areas of dentin are harder, denser, less sensitive, and more protective of the pulp against subsequent irritations.

Sclerosis resulting from aging is called **physiologic** dentin sclerosis, while sclerosis resulting from irritation is called **reactive** dentin sclerosis.

Clinically, sclerotic dentin is shiny, darkly colored, and feels hard to explorer tip, while the freshly cut normal dentin lacks the shiny reflective surface and allows some penetration by the sharp explorer tip (softer than sclerotic dentin). It is not uncommon to find sclerotic dentin under old restoration which usually shows a great amount of discoloration.

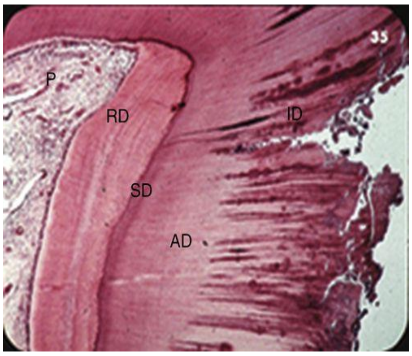
The apparent function of sclerotic dentin is to wall off the lesion by blocking (sealing) the tubules. The permeability of this type of dentin is greatly reduced in comparison to normal dentin because of the decrease in the tubule lumen diameter.

3. Reparative Dentin (Tertiary D., Reactionary D.)

This type of dentin is the outcome of odontoblastic response to irritation occurring mainly during secondary dentinogenesis and is caused by dental abrasion, attrition, cavity preparation, erosion or dental caries.

Caries advancing at a moderate rate with high acid production results in degeneration and death of the odontoblasts and their processes in the tubules, as well as mild inflammation of the pulp.

In about 15 days, new odontoblasts are differentiated from mesenchymal cells of the pulp, and these replacement odontoblasts lay down the reparative dentin that is confined to the localized irritated area of the pulp cavity wall.



The structure of reparative dentin is more often irregular, atubular dentin depending on the severity of the stimulus. Reparative dentin is a defense reaction localized to the area of injury.

(**reactionary** dentin is the result of irritation of postmitotic odontoblasts, whereas **reparative** dentin is formed by odontoblasts or odontoblast-like cells which differentiate from pulp cells after the cell death of primary odontoblasts).

4. Infected Dentin

It is softened and contaminated with bacteria. It includes the superficial necrotic dentin tissue or zone. Clinically, necrotic dentin is wet mushy, easily removable mass. Histologically, this dentin is structureless with granular appearance and contain mass of bacteria. Remnant of distorted dentinal tubules filled with bacteria may be seen. The deeper infected dentin is dry . It is easily removed by hand instrument and flake off in layers parallel to the DEJ.

If the lesion is progressing slowly, there will be a zone of sclerotic dentin subjacent to the demineralized dentin. When this occurs, it represents the ideal excavation depth, since the sclerotic dentin is a natural barrier that blocks the penetration of toxin and acids.

5. Affected Dentin

It is softened dentin that still not invaded by bacteria and has intact tubules containing odontoblastic processes that have porous surface and contain crystalline material. This dentin is capable of remineralization, provided the pulp remains vital.

In slowly advancing lesion, we should remove all softened dentin down to the identificationable zone of sclerotic dentin. In rapidly advancing lesion, there is little clinical evidence by texture and color change to indicate the limit of the infected dentin. Caries indicator could be helpful to distinguish between infected and affected dentin.

6. Inflammation of the pulp.

Inflammatory Conditions of the Pulp

In order to select the proper choice of treatment, the status of the pulp must be determined with accuracy. Sufficient irritation induces injury; incites inflammation. Histologically and physiologically, the inflammation is similar to that occurring in other connective tissues. However, the long term response of the pulp to severe irritation is different than in other tissues. In contrast to most soft tissues, the pulp has no room in which to swell. This inability to swell may well lead to increasing cell death in an ever widening area. It is generally the coronal pulp that is injured and it lacks collateral blood supply; extra nutrition and defenses cannot be arranged quickly to the area. Another factor working to the detriment of the injured pulp is inflammation itself. Inflammation is a protective response. The immune response may destroy normal cells as well as foreign substances. Again, the pulp, with its compromised blood supply is unable to cope with this increasingly severe damage.

Clinically normal pulp	Vital, asymptomatic healthy pulp
Reversible pulpitis Acute Chronic	Presence of mild inflammation where the pulp is capable of healing
Irreversible pulpitis Acute Chronic	Presence of more degenerative processes within the pulp whereby the pulp is not capable of healing
Pulp necrosis Necrobiosis (partial necrosis) Complete pulp necrosis	The end result of irreversible pulpitis. Subsequent bacterial invasion will lead to an infected pulpal necrosis

Reversible Pulpitis

This refers to a pulp that has mild inflammation due to pulpal irritation that is capable of healing and returning to a clinically normal pulp if appropriate treatment therapy is performed. Reversible pulpitis is a result of caries, trauma, defective or new restorations, mechanical pulp exposures, tooth brush abrasion, cracked tooth syndrome or recent subgingival scaling and curettage. The pain is characterized as mild to severe elicited by stimuli (e.g. thermal, biting, sweet or sour stimuli)

Irreversible Pulpitis

A pulpal condition is usually caused by deep dental caries or restorations, previous pulp capping procedure, crack or any other pulpal irritant. Spontaneous pain may occur or be precipitated by thermal or other stimuli. The pain may last for several minutes to several hours described as a sharp or dull exaggerated painful response that lingers after the stimulus has been removed. The nature of the pain depends on the type of nerve fiber responding to the inflammation within the pulp (either A delta fibers that mediate sharp pain or C fibres responsible for dull throbbing pain)

The most severe reaction occurs at the time of actual pulp exposure. In progressive order the status of the pulp in the response to caries are as follows:

1- Healthy pulp.
2- Hyperemia.
3- Acute pulpitis.
4- Chronic partial pulpitis (without necrosis).
5- Chronic partial pulpitis (with necrosis).
6- Chronic total pulpitis with partial necrosis.
7- Total necrosis of the pulp.
8- Acute pulpitis superimposed on chronic pulpitis.

Pulpal diseases are broadly divided into reversible and irreversible pulpitis and are based on the ability of the inflamed dental pulp to return to a healthy state or not.

1-Healthy Pulp

Normal pulp, free of disease, or healthy, may show a wide variation in it histological structure according to its age and function. There are no inflammatory cells.

2- Hyperemia

Hyperemia is a physiologic term meaning an increase in blood flow through tissue. In histology, dilated and congested vessels were seen. Pulp could not be inflamed. About 41% of the carious teeth did have hyperemia, suggesting that frequently this may be an early sign of inflammation. Because the early vascular events of hyperemia precede or are an early component of inflammation, the removal of the precipitating cause of hyperemia should revert the microcirculation to its normal state.

3- Acute Pulpitis

This occurs as a sequent to various operative procedures including mechanical pulp exposure also following deep scaling and curettage. Always an acute reaction develops beneath the affected dentinal tubules. Acute infection could superimpose itself on an existing chronic inflammatory reaction e.g. the operative manipulation will induce an acute reaction on an already existing chronic reaction due to the previous restoration. **Acute pulpitis** is extremely sensitive to temperature. Cool air is sufficient to trigger the pain. **Chronic pulpitis** on the other hand is often completely without symptoms.

In **reversible, acute pulpitis**, the tooth reacts to sweetness, cold and heat. The pain lasts for a short while only. The sensitivity test is positive. If caries can be removed without opening the pulp, symptoms disappear. The pulp can be kept vital. This acute form of pulpitis is therefore reversible.

Symptoms:

1.sharp pain that stay for few minutes.

2.pain disappear by itself or by analgesic.

In **irreversible pulpitis**, which may be acute or chronic, the tooth is permanently painful. The dentin is frequently destroyed up to the pulpal cavity and cariously altered. Pain continues even after caries removal. The tooth's sensitivity to touch and biting is joined by decreasing or lacking reaction to a sensitivity test. The damaged pulp cannot be reversed to its original healthy state, it is irreversible.

Symptoms:

1.sharp spontaneous, intermittent or continuous in nature.

2.pain remain after removal of stimulus.

3.In later stage pain is sever,boring and throbbing in nature and increase with hot stimulus.

4.pain may be relieved by cold water.

Histologic changes associated with inflammation: The odontoblast cells may be destroyed or irrupted by edema. Often evidenced by increased eosinophilia of the connective tissue. Marked dilatation of lymphatics and of blood vessels is accompanied by packing of erythrocytes and pavementing of leukocytes along the vessel walls, and within capillaries. Infiltrate of leukocytes, is soon evident around the dilated vessels. This reaction lasts 3 days and it either disappears and resolves into a repair process or it changes into a chronic inflammatory reaction depending on the irritant “if it persists”.

The clinical manifestation is mild pain during hot and/ or cold application, the pain remain as long as the stimulus remains.

4- Chronic Partial Pulpitis (without Necrosis)

This develops from deep dental caries, pulp exposure, operative procedures, deep periodontal lesion, and orthodontic tooth movement. The inflammation is confined to the coronal portion of the pulp. Histologically the chronic form usually dominated-small Lymphocytes, Monocytes, Macrophages, and plasma cells are abundant.

In children and young adults, the hyperplastic tissue reaction occurs because the young dental pulp has a rich blood supply and favorable immune response that is more resistant to bacterial infection. This is known as pulp polyp, also known as chronic hyperplastic, is an uncommon and specific type of inflammatory hyperplasia that is easy to bleed by touch. The pulp polyp is usually an incidental finding that occasionally mimics reactive and neoplastic diseases of the gingiva and adjacent periodontium, it's easy to be differentiated from gum polyp by follow the origin of each by using a probe. The pulp polyp is the result of both mechanical irritation and bacterial invasion into the pulp of a tooth that exhibits significant crown destruction due to trauma or caries. Usually, the entire dentinal roof is exposed with the crown of a carious tooth. The large exposure of pulpal tissue to the oral environment and bacterial invasion results in a chronic inflammatory response that stimulates granulation tissue reaction. Treatment of a pulp polyp includes: The more conservative vital pulpotomy treatment has been successful in selected cases when only the coronal pulp is affected (there's no necrosis in the pulp). Or either root canal therapy or extraction of the tooth when there is necrosis in the pulp.

5- Chronic Partial Pulpitis with Partial Necrosis

It develops from the same irritant as above but with the persistence of such irritant. This causing area of liquefaction or coagulation necrosis with the inflammatory lesion has extended to deeper pulp tissue.

Painful symptoms may occur, these areas of liquefaction necrosis are called “pulp abscess” since they are surrounded by disintegrated polymorphonuclear leukocytes, collagen fibers and chronic inflammatory cells. The pain is spontaneous and is due to the pressure of the abscess on the nerve surrounding it. Sometimes the pain may last for ½ hr, and it doesn’t disappear with analgesics.

Radiograph should be taken when the tooth in such condition. It could be exposed (the caries has gone to the pulp- chronic open pulpitis) or it could be closed (the effected caused by bacterial toxins or sever irritant that the pulp can't recover).

The available treatment for this type of pulpitis is either endodontic (root canal treatment) or tooth extraction.

6- Chronic Total Pulpitis with Partial Necrosis

This develops with the extension of the inflammation to involve the entire pulp tissue (coronal and radicular) due to the persistence of the irritant and the development of liquefaction necrosis within the inflammatory area or coagulation necrosis. We get severe pain, sometimes lasting for many hours or when the patient sleeps this will increase the pressure inside the pulp and cause throbbing pain. The available treatment for this type of pulpitis is either endodontic (root canal treatment) or tooth extraction.

7- Total Necrosis of the Pulp

Pulp in which the cells have died as a result of coagulation or liquefaction. histologically, coagulation cell means is still recognizable but the intracellular details have disappeared. While liquefaction necrosis, the entire outline of the cell has disappeared, and liquefied area. There is a dense zone of polymorphonuclear leukocytes with cells of chronic inflammation.

8- Acute Pulpitis Superimposed on Chronic Pulpitis

There's severe pain especially at night till the abscess is formed then there's slight relief but not complete relief unless we do drainage through the tooth (access opening) or surgical incision with antibiotic cover, we should see the patient within few days and then treatment is continue by root canal treatment or extraction.

Operative Dentistry

Dental Laser

Definition

The term ***LASER*** is an acronym for '***Light Amplification by the Stimulated Emission of Radiation***'. As its first application in dentistry by Miaman, in 1960, the laser has seen various hard and soft tissue applications.

There are two types, there are hard lasers, such as, Carbon dioxide (CO_2), Neodymium Yttrium Aluminum Garnet (Nd: YAG), and Er:YAG, which offer both hard tissue and soft tissue applications, but have limitations due to high costs and a potential for thermal injury to tooth pulp, whereas, on the other hand in cold or soft lasers, based on the semiconductor diode devices, which are compact, low-cost devices used predominantly for applications, are broadly termed as low-level laser therapy (LLLT). On account of the ease, efficiency, specificity, comfort, and cost over the conventional modalities, lasers are indicated for a wide variety of procedures in dental practice.

Carbon dioxide Laser

The CO_2 laser wavelength has a very high affinity for water, resulting in rapid soft tissue removal and hemostasis with a very shallow depth of penetration. Although it possesses the highest absorbance of any laser, disadvantages of the CO_2 laser are its relative large size and high cost and hard tissue destructive interactions.

Neodymium Yttrium Aluminum Garnet Laser

The Nd: YAG wavelength is highly absorbed by the pigmented tissue, making it a very effective surgical laser for cutting and coagulating dental soft tissues, with good hemostasis. In addition to its surgical applications, there has been research on using the Nd: YAG laser for nonsurgical sulcular debridement in periodontal disease control and the Laser Assisted New Attachment Procedure (LANAP).

Erbium Laser

The erbium 'family' of lasers has two distinct wavelengths, Er, Cr: YSGG (yttrium scandium gallium garnet) lasers and Er: YAG (yttrium aluminum garnet) lasers. The erbium wavelengths have a high affinity for hydroxyapatite and the highest absorption of water in any dental laser wavelengths. Consequently, it is the laser of choice for treatment of dental hard tissues. In addition to hard tissue procedures, erbium lasers can also be used for soft tissue ablation, because the dental soft tissue also contains a high percentage of water.

Diode Laser

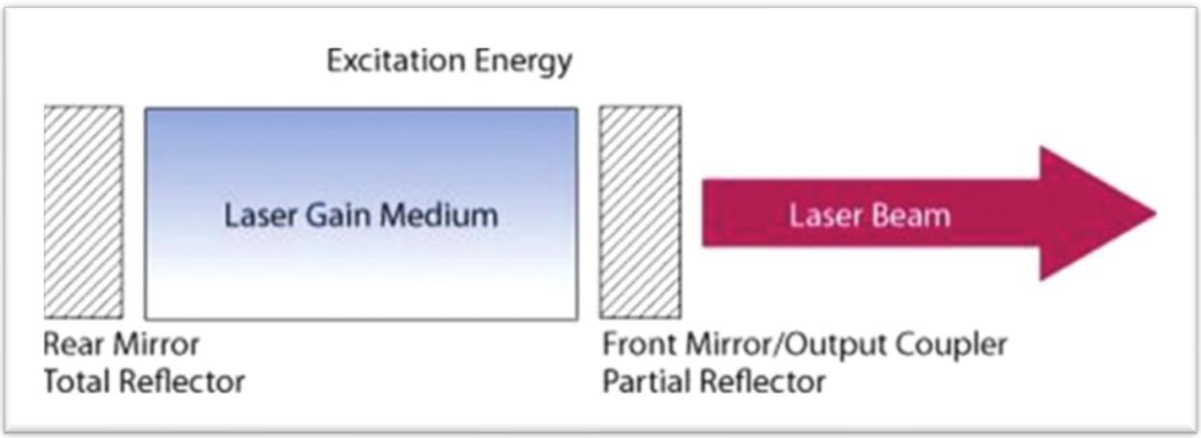
Used for specific procedures include aesthetic gingival re-contouring, soft tissue crown lengthening, exposure of soft tissue impacted teeth, removal of inflamed and hypertrophic tissue, frenectomies.

Excimer lasers

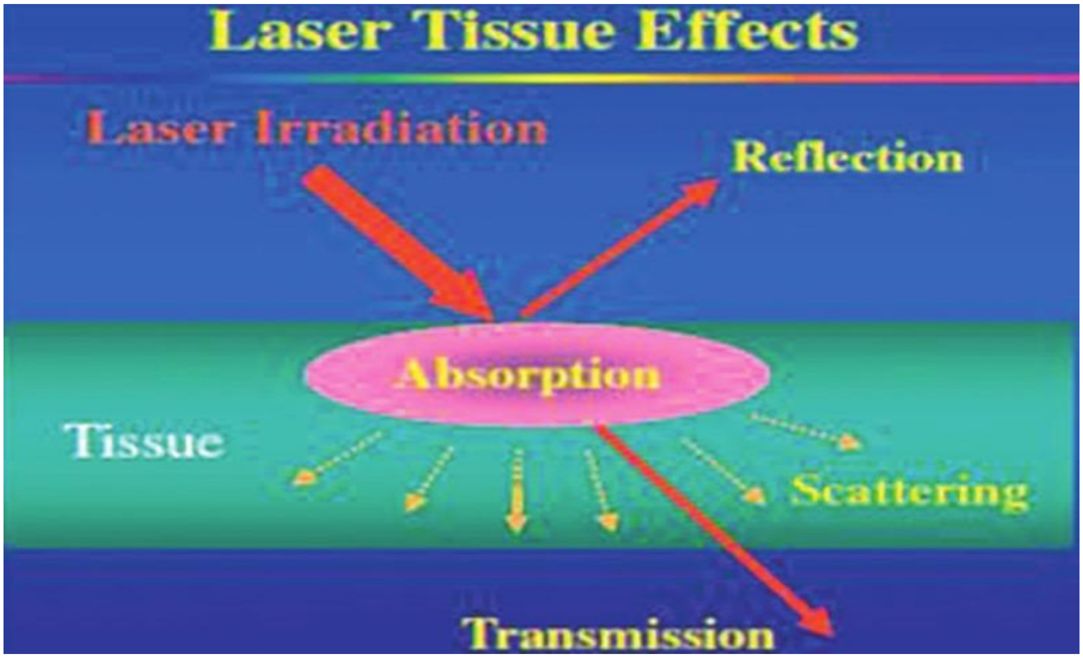
Constitute a class of electronically excited molecular gas lasers that emit high intensity, short duration pulses of ultraviolet light. They define a different regime of laser-tissue interaction because these tJV photons are sufficiently high-energy to result in bond-breaking in organic molecules. This characteristic, in combination with the fact that excimer pulses are very short (in the order of 10-100 ns), gives rise to the observation that minimal thermal effects result from excimer laser irradiation

Mechanism of Laser Action

Laser light is a monochromatic light and consists of a single wavelength of light. It consists of three principal parts: An energy source, an active lasing medium, and two or more mirrors that form an optical cavity or resonator. For amplification to occur, energy is supplied to the laser system by a pumping mechanism, such as, a flash-lamp strobe device, an electrical current, or an electrical coil. This energy is pumped into an active medium contained within an optical resonator, producing a spontaneous emission of photons. Subsequently, amplification by stimulated emission takes place as the photons are reflected back and forth through the medium by the highly reflective surfaces of the optical resonator, prior to their exit from the cavity via the output coupler. In dental lasers, the laser light is delivered from the laser to the target tissue via a fiberoptic cable, hollow waveguide, or articulated arm . Focusing lenses, a cooling system, and other controls complete the system. The wavelength and other properties of the laser are determined primarily by the composition of an active medium, which can be a gas, a crystal, or a solid-state semiconductor.



The light energy produced by a laser can have four different interactions with a target tissue: Reflection, Transmission, Scattering, and Absorption . When a laser is absorbed, it elevates the temperature and produces photochemical effects depending on the water content of the tissues. When a temperature of 100°C is reached, vaporization of the water within the tissue occurs, a process called *ablation*. At temperatures below 100°C, but above approximately 60°C, proteins begin to denature, without vaporization of the underlying tissue. Conversely, at temperatures above 200°C, the tissue is dehydrated and then burned, resulting in an undesirable effect called *carbonization*.



Applications of laser in conservative dentistry

1. Aesthetic gingival re-contouring and crown lengthening

With the advent of the diode laser, many clinicians are choosing to include optimization of gingival aesthetics as part of the comprehensive orthodontic treatment, whereas, conventional gingivectomy is associated with pain, discomfort, and bleeding.

2. Photochemical effects

The argon laser produces high intensity visible blue light (488 nm), which is able to initiate photopolymerization of light-cured dental restorative materials, which use camphoroquinone as the photoinitiator. Argon laser radiation is also able to alter the surface chemistry of both enamel and root surface dentine, hich reduces the probability of recurrent caries. The bleaching effect relies on the specific absorption of a narrow spectral range of green light (510-540 nm) into the chelate compounds formed between the apatites, porphyrins, and tetracycline compounds. Argon and Potassium Titanyl Phosphate ($KTiOPO_4$, KTP) lasers can achieve a positive result in cases that are completely unresponsive to conventional photothermal 'power' bleaching.

3.Cavity preparation, caries, and restorative removal

Various studies depict the use of Er: YAG, since 1988, for removing caries in the enamel and dentine by ablation, without the detrimental effect of rise in temperature on the pulp, even without water-cooling, with low '*fluences*' laser (LLLT), similar to air-rotor devices, except that the floor of the cavity is not as smooth. The Er: YAG laser is capable of removing cement, composite resin, and glass ionomer.

4.Etching

Laser etching has been evaluated as an alternative to acid etching of enamel and dentine. Enamel and dentine surfaces etched with (Er, Cr: YSGG) lasers show micro-irregularities and no smear layer. Adhesion to dental hard tissues after Er: YAG laser etching is inferior to that obtained after conventional acid etching.

5.Treatment of dentinal hypersensitivity

Dentinal hypersensitivity is one of the most common complaints in clinical dental practice. Comparison of the desensitizing effects of an Er: YAG laser with those of a conventional desensitizing system on cervically exposed hypersensitive dentine showed that desensitizing of hypersensitive dentine with an Er: YAG laser is effective, and maintenance of a positive result is more prolonged than with other agents.

6.Diagostic application

The laser is being used for diagnostic purposes in clinical dental practice as well as in research purposes. DIAGNOdent which is used for caries detection.

7.Dental Infections

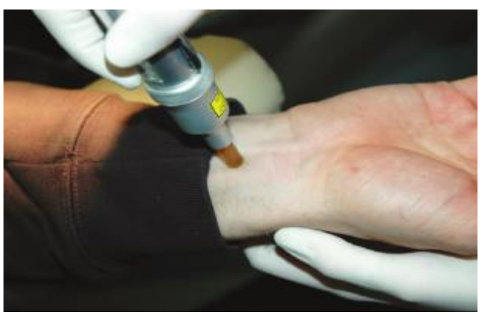
In any case of a dental infection, the laser can be applied to the submandibular lymph nodes to increase the lymphatic flow of the infected area, reduce the infammatory cells and bring neutrophils to the site of infection for faster healing. Laser therapy will not preclude the use of antibiotics in most cases but will help to potentiate the uptake of the antibiotic into the blood stream.

8.***Analgesia***

Laser is being used by many dentists and pedodontists for analgesia of primary tooth restorations. When operated at pulse rates between 15 and 20 Hz, at pulse energies below the ablation threshold of tooth structure, the erbium laser energy penetrates into the tooth, and is directed along hydroxyapatite crystals (which function like waveguides) toward the dental pulp. Laser irradiation decreases the conduction of C-fibers from the pulp and stimulates the release of endorphins and serotonin, and increases oxygenation and lymphatic drainage, which results in decreased pain sensation (analgesia).

9.Nausea and Gagging

Application of the laser to the P6 acupuncture point of the wrist will decrease the gagging and nausea sensations felt by many patients during dental treatments, impressions and X-rays.



10.Endodontics

In endodontics, lasers have been used as adjuvant treatment in both low-intensity laser therapy and high intensity laser treatment. Low-intensity laser therapy induces analgesic, anti-inflammatory and improving tissue healing processes and less postoperative discomfort for patients.**The clinical application of low-intensity laser in endodontic therapy has been**

considered useful in: post pulpotomy (with the laser beam applied directly to the remaining pulp and on the mucosa toward the root canal pulp); post pulpectomy (with the irradiation of the apical region); periapical surgery (irradiating the mucosa of the area corresponding to the apical lesion and the sutures)

The clinical indications for high-intensity laser radiation in endodontic treatment are:
a.Bacterial reduction. Intracanal radiation absorbed by tissue substances produce a thermal effect capable of eliminating microorganisms.

b. Dentinal root canal treatment. Depending on the interaction between the wavelength emission and the target tissue, high-intensity lasers are capable of performing morphological superficial changes on root dentin, influencing the permeability of the walls and the adaptability of the root filling to the root dentin.

c. Intracanal soft tissue vaporization. The potential of specific wavelengths to vaporize soft tissue allows the removal of intracanalicular granulation tissue present in internal root resorption cases. In addition, disinfection will be achieved in contaminated root resorbed canals due to the bactericidal effect of thermal interaction.

D. Endodontic surgery. The advantages of laser application in endodontic surgery are identical to those that have been reported for other oral surgical procedures.

Laser safety

While most dental lasers are relatively simple to use, certain precautions should be taken to ensure their safe and effective operation. First and foremost is protective eyewear by anyone in the vicinity of the laser, while it is in use. This includes the doctor, chairside assistants, patient, and any observers such as family or friends. It is critical that all protective eyewear worn is wavelength-specific. Additionally, accidental exposure to the non-target tissue can be prevented through the use of warning signs posted outside the nominal hazard zone, limiting access to the surgical environment, minimizing the reflective surfaces, and ensuring that the laser is in good working order, with all manufacturer safeguards in place. With regard to prevention of possible exposure to infectious pathogens, high volume suction should be used to evacuate any vapor plume created during tissue ablation, and normal infection protocols should be followed. Each office should have a designated Laser Safety Officer to supervise the proper use of the laser, coordinate staff training, oversee the use of protective eyewear, and be familiar with the pertinent regulations.