Endodontics

Lec.6 Microbiology in Endodontics د. عبدالله الجوهر

In 1894, Miller's hypotheses stated that bacteria are the causative agent of apical periodontitis. Although there are other reasons such as chemical and physical irritation can affect the pulp. This results in various degrees of inflammation. More than 400 different microbial species have been found in infected root canals, usually in combinations. Fungi have been occasionally found in endodontic infections.
Change in the composition of the microbiota is due to changes in environmental conditions, particularly regarding oxygen tension and nutrient availability. In the very initial phases of the pulpal infectious process, facultative bacteria predominate. After a few days or weeks, oxygen decrease within the root canal as a result of pulp necrosis and consumption by facultative bacteria. Oxygen supply is affected with loss of blood circulation in the necrotic pulp which develops an obligate microbiota.

Root canal microbes

The most prevalent named bacterial species detected in primary infections belong to diverse genera of
1-Gram-negative bacteria: Fusobacterium, Dialister, Porphyromonas, Prevotella, Tannerella, Treponema, Campylobacter and Veillonella.
2-Gram-positive bacteria: Parvimonas, Filifactor, Pseu doramibacter, Olsenella, Actinomyces, Peptostreptococcus, Streptococcus, Propionibacterium, and Eubacterium bacteria.

Nutrition of Bacteria

The main sources of nutrients for bacteria colonizing the root canal system include:
(1) Necrotic pulp tissue.
(2) Proteins and glycoproteins from tissue fluids and exudate that seep into the root canal system via apical and lateral foramens.
(3) Components of saliva that penetrate coronally into the root canal.
(4) Products of the metabolism of other bacteria.

Pulpal pathways

Bacteria, usually from dental caries, is 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). 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.

Host-parasite interaction

This interaction depends on:

1- Microbial virulence factors

These are microbial products, structural components, or strategies (biofilm formation) in the microorganism that gives it the capability to cause tissue damage. The ability of a microorganism to cause disease is regarded as pathogenicity. Virulence indicates the degree of pathogenicity of a microorganism. Some microorganisms cause disease in a host and are called primary pathogens while other microorganisms cause disease only when host defenses are decreased which are called opportunistic pathogens. Microbial products as endotoxins, endotoxin enzymes, metabolic end products affect the microbial virulence.

2- Host resistance factors

a) Platelet factors.

b) Serum factors as antibodies (IgG, IgM)

c) Leukocytic factors as lysozymes which hydrolyzes bacterial cell wall of Gram +ve bacteria.

d) Macrophages factors.

e) Lymphocytic factors as lymphotoxin and macrophage activating factor.

f) Salivary factors as lysozyme, antibodies (IgA)

Biofilm and Bacterial Interactions

The community-forming ability is essential for microbial survival in all environments. Most of the microorganisms in nature grow and function as members of metabolically integrated communities called the biofilms. Biofilm can be defined as a multicellular microbial community embedded by cells that are firmly attached to a surface and enmeshed in a self-produced matrix

of extracellular polymeric substance, usually polysaccharide. The ability to form biofilms is regarded as a virulence factor and biofilm infections account for an estimated 65% to 80% of bacterial infections. Biofilms are structurally and dynamically organized complex biologic systems.

Spread of bacteria in the body

1- Bacteremia

Bacteria especially alpha hemolytic streptococci can enter the bloodstream during routine dental treatment. In normal person the bacteria are killed within 10 minutes by the body defense mechanism.

Infective endocarditis happens in bacteremia to patients with a history of rheumatic fever, with cardiac murmur or mitral valve prolapse.

2- Septicemia

It is a serious life-threatening bacterial (and their products) invasion of the bloodstream. It happens when body defense is low or when the infection overwhelming. It is associated with severe signs and symptoms.

3- Cellulitis

It is an acute infection of the alveolar and loose connective tissue and it is a diffused spread of infection. Clinically in endodontics cellulitis is called flare-up and it happens during access opening because of the environmental change of oxygen level in the root canal which enhances the action of the facultative bacteria and during instrumentation and obturation when debris or obturation material extrude the apical foramen.

Bacterial culturing in endodontics

There are three reasons for culturing root canal contents:

1- To determine the bacteriologic status of the root canal.
2- To assess the efficiency of the debridement procedure.
3- To isolate microbial flora for antibiotic sensitivity and resistance profiles in cases of persistent infections.

Irrigation in Endodontics

Every root canal system has spaces that cannot be cleaned mechanically. The only way to clean webs, fins and anastomoses is through effective use of irrigation solution. In order to get the maximum efficiency from irrigant, irrigant must reach the apical portion of the canal.

Properties of ideal irrigant solution:

- Anti microbial properties
- Tissue solvent.
- Flush debris.
- Lubricant.
- Eliminate the smear layer.
- Low toxicity level.

Commonly used irrigating solutions:

I. Chemically non active solution:

- Water.
- Saline.
- Anesthesia.

These irrigating solutions act as lubricant, flush debris and have Low toxicity level.

II. Chemically active materials:

- Alkalis : sodium hypochlorite
- Antibacterial agents : chlorhexidine
- Oxidizing agents: hydrogen peroxide
- Chelating agents: EDTA (ethylene diamine tetra acetic acid).

Sodium hypochlorite (NaOcl)

Clear, pale green-yellow liquid with strong odor of chlorine. It is a potent antimicrobial agent, killing most bacteria instantly on direct contact. It also effectively dissolves necrotic and vital pulp tissue. It is the most advocated irrigant, inexpensive and readily available.

Properties of NaOcl:

- Anti microbial properties
- Tissue solvent. dissolve vital and non vital tissue.
- Flush debris.
- Lubricant.

Concentration

NaOCl can be used in concentrations between 0.5% and 6%. According to several studies the lower and higher concentrations are equally efficient in reducing the number of bacteria in infected root canals. However, The time needed to inhibit bacterial growth and tissue dissolving effect of NaOcl irrigant are related to its concentration ,but so is it is toxicity . Increasing the temperature of hypochlorite irrigant to 40 or 60 °C, significantly increased its antimicrobial and tissue-dissolving effects.

Limitation of NaOCl :

- Unpleasant taste
- Relative toxicity
- Inability to remove smear layer

Sodium hypochloride accident

The unintentional injection of NaOCl into apical tissue due to wedging of irrigation needle or excessively high pressure in teeth with wide open foramen or root resorption, resulting in:

- Immediate severe pain for 2-6 minutes.
- immediate edema in adjacent soft tissue because of perfusion to the loose connective tissue.
- Extension of edema to a large site of the face such as cheeks, peri- orbital region, or lips.
- Ecchymosis on skin or mucosa as a result of profuse interstitial bleeding.

Management

- Inform the patient about the cause and nature of the complication.
- Immediately irrigate with normal saline to decrease the soft-tissue irritation by diluting the NaOCl.
- Let the bleeding response continue as it helps to flush the irritant out of the tissues.
- Recommend ice bag compresses for 24 hours (15-minute intervals)to minimize

swelling.

- Recommend warm, moist compresses after 24 hours (15-minute intervals).
- pain control with strong analgesics for 3 to 7 days
- Prophylactic antibiotic coverage for 7 to 10 days to prevent secondary infection or spreading of the present infection.

Chlorhexidine (CHX)

Properties

- Anti microbial properties (broad spctrum antimicrobial agent)
- Flush debris.
- Lubricant.
- Low toxicity level.

Concentration

- 0.2% is concentration commonly used for chemically plaque control in oral cavity.
- 2% is concentration used as root canal irrigation.

Limitation

- Unable to dissolve remaining necrotic tissue.
- Less effective on gram negative than on gram positive.
- Unable to remove smear layer.

Hydrogen Peroxide H2O2

It is a clear, colorless, odorless liquid. H2O2 is active against viruses, bacteria, and yeasts. It has been particularly popular in cleaning the pulp chamber from blood and tissue remnants, but it has also been used in canal irrigation.

Properties

- Anti microbial properties (broad spctrum antimicrobial agent)
- Flush debris.
- Lubricant.

Concentration

It is recommended to be used in 3% concentration for endodontic irrigation.

Limitations

- Unable to remove smear layer.
- Always use Naocl last because Hydrogen peroxide release nascent oxygen on contact with organic tissue which may build up pressure and causes pain .
- Soft tissue emphysema may occur when hydrogen peroxide irrigant enforced beyond the apical foramen.

MTAD

A mixture of tetracycline isomer, acid, and detergent (doxycycline, citric acid, and the detergent Tween-80).

Properties

- Anti microbial properties (broad spectrum antimicrobial agent)
- Flush debris.
- Lubricant.
- Eliminate the smear layer.
- Low toxicity level.

EDTA (ethylene-diamine tetra-acetic acid)

It is chelating agent used for lubrication, emulsification and holding debris in suspension.

Mechanism of action

EDTA functions by forming calcium chelate solution with calcium ions of dentin which make it more friable and thus dentin become easily to manipulate by instrumentation.

Properties

- 17% EDTA (pH 7)
- EDTA has no antibacterial activity.
- It effectively removes smear layer by chelating the inorganic component of the dentine.
- Aid in mechanical canal shaping.
- The optimal working time of EDTA is 15 minutes, after which time no more chelating action can be expected.

The smear layer

The smear layer is a layer of debris, compromising both organic and inorganic components, found on canal walls after endodontic instrumentation, it is typically 1-2

um in thick. It is made up largely of particularly dentin debris removed by endodontic instrument during canal preparation but may also contains remnants of pulp tissue and microorganisms. Presence of smear layer on the canal walls potentially interfere with the adaptation of sealer against canal wall and may create avenue of leakage of microorganisms by act as substrate for microbial proliferation.

Smear layer removal
Can be accomplished by one of the following ways :

1. Use of chelating agents (17% EDTA) during the cleaning and shaping. Upon complete the root canal shaping soak the canal for 1 minute with liquid EDTA, then rinse the canal thoroughly with NaOcl .
2. After irrigation with NaOcl Soak the canal for a 5 minutes with MTAD as final irrigant.

Dry canal with paper points, so it is now ready for obturation .

Irrigation method:

- It is strongly recommended that the needle lie passively in the canal and not engage the walls.
- A 27- or 30-gauge side vented irrigation needle is preferred
- The solution must be introduced slowly.
- The irrigating needle should be bent to allow easier delivery of the solution and to prevent deep penetration of the needle.
- Care must be taken with irrigants like sodium hypochlorite to prevent accidents.

Methods for irrigants activation

- **Gutta-percha Points agitation**
  Use of apically fitting gutta-percha cone in an up-and-down motion at the working length. Although this facilitates the exchange of the apical solution, but the overall volume of fresh solution in the apical canal is likely to remain small.
- **EndoActivator**
  It is based on sonic vibration (up to 10,000 rpm) of a plastic tip in the root canal. The system has 3 different sizes of tips that are easily attached to the battery operated handpiece that creates the sonic vibrations. It allow more irrigant penetration and mechanical cleansing compared with needle irrigation, with no increase in the risk of irrigant extrusion through the apex.
- **Ultrasound**
  Ultrasound is sound energy with frequency above 25 KHZ. Passive ultrasonic

irrigation has shown to clean root canals or eliminate bacteria from the walls better than conventional methods. When a small file (size 10-20) is placed freely in the center of the canal following preparation and ultrasonic activation is given, the ultrasonic energy pass through irrigating solution and exerts its (acoustic streaming effect).

- **EndoVac**
  The EndoVac system is based on a negative-pressure approach whereby the irrigant placed in the pulp chamber is sucked down the root canal and back up again through a thin needle with a special design.

Intracanal medicaments

The purpose of intracanal medicaments is: 1) Destroy the remaining bacteria and also limits the growth of new arrivals. 2) Useful in treatment of apical periodontitis, e.g. in cases of inflammation caused due to over instrumentation.

1- Calcium hydroxide:

One of the intracanal agents that are effective in inhibiting microbial growth in canals is calcium hydroxide. The antimicrobial activity of calcium hydroxide is a result of the alkaline pH, and this agent may aid in dissolving necrotic tissue remnants and bacteria and their byproducts. Inter-appointment use of calcium hydroxide in the canal demonstrates no pain-reduction effects. Calcium hydroxide has been recommended for use in teeth with necrotic pulp tissue and bacterial contamination. It probably has little benefit in teeth with vital pulps. Calcium hydroxide should be placed as a powder mixed with a liquid (e.g., local anesthetic solution, saline, or sterile water) to form a slurry; or it can be introduced into the canal as a proprietary paste supplied in a syringe. A Lentulo spiral is effective and efficient for placement. Spinning the paste into the canal by rotating a file counterclockwise and using an injection technique is not as effective.

2- Phenols and Aldehydes; like Camphorated monochloro phenol (CMCP) and Tri cresol formalin:

The majority of the phenols and aldehydes have nonspecific action and can destroy host tissues in addition to microbes. Historically it was thought that these agents were effective, although their use was based on opinion and empiricism. The phenols and aldehydes are toxic, and the aldehydes are fixative agents. When placed in the radicular space, they have access to the periradicular tissues and the systemic circulation. Research has demonstrated that their clinical use is not justified.

3- Corticosteroids; like Ledermix:

Corticosteroids are anti-inflammatory agents that have been advocated for reducing postoperative pain by suppressing inflammation. The use of corticosteroids as intracanal medicaments may diminish lower level postoperative pain in certain situations; however, evidence also

suggests that they may be ineffective, particularly with higher pain levels. Irreversible pulpitis and acute apical periodontitis are examples of conditions in which steroid use might be beneficial.

4- Chlorhexidine:

Chlorhexidine has recently been advocated as an intracanal medicament. A 2% gel is recommended, which can be used alone or mixed with calcium hydroxide.

5- Triple-Antibiotic Paste

The triple-antibiotics regimen, composed of metronidazole, ciprofloxacin, and minocycline. The clinical effectiveness of the triple-antibiotic paste in the disinfection of immature teeth with apical periodontitis has been reported. One potential concern of using an intracanal antibiotic paste is that it may cause bacterial resistance. Additionally, intracanal use of minocycline can cause tooth discoloration, creating potential cosmetic complications. For this reason, a dual paste (metronidazole, ciprofloxacin) and, alternatively, abandonment of this protocol in favor of Ca(OH)2 have been considered.

Antibiotics in endodontics

Antibiotics are used when infection spreads to the alveolar bone with swelling of the area above the accused tooth and drainage does not relieve the swelling.

Most of the bacterial species involved with endodontic infections are susceptible to penicillins, which make them first-line drugs of choice. In more serious cases, including life-threatening conditions, combining amoxicillin with clavulanic acid or metronidazole can achieve optimum antimicrobial effects as a result of the extended spectrum of action to include penicillin-resistant strains. Erythromycin is used in cases of penicillin allergy.

As a conclusion unnecessary use of antibiotics increases the risk for developing resistant species of bacteria.