# Endodontic Microbiology

**Assis. Prof. Dr. Firas Albaaj**

## Microbial causation of apical periodontitis

Apical periodontitis is an inflammatory disease of microbial etiology primarily caused by infection of the root canal system. Endodontic infections usually develop after pulpal necrosis or in cases in which the pulp was removed for the treatment. Although fungi and most recently archaea and viruses have been found in endodontic infection, bacteria are the major microorganisms implicated in the etiology of the apical periodontitis. Bacteria colonizing the root canal system contact the periradicular tissues via apical and lateral foramina. As a consequence of the encounter between the bacteria and the host defenses, inflammatory changes take place in the periradicular tissue and give rise to development of apical periodontitis.

The ultimate goal of the endodontic treatment is either to prevent the development of apical periodontitis or to create adequate conditions for periradicular tissue healing.

## Routes of root canal infection

Under normal conditions, the dental pulp and dentin are sterile and isolated from oral microorganisms by overlying enamel and cementum. There are situations in which the integrity of these protective layers is breached (e.g., as a result of caries, trauma-induced fractures and cracks, restorative procedures, scaling and root planning, attrition, or abrasion) or naturally absent (e.g., because of gap in the cementoenamel junction at the cervical root service). The main portals of pulp infection are dentinal tubules, direct pulp exposure, periodontal disease, and anachoresis.

### Dentinal tubules

Whenever dentin is exposed, the pulp is put at risk for infection because of the permeability of normal dentin dictated by its tubular structure. Dentin permeability is increased near the pulp because of the larger diameter and higher density of tubules. Exposed dentin can challenge by microorganisms present in carious lesions, in saliva bathing the exposure area, or in dental plaque formed onto the exposed area.

### Direct pulp exposure

Direct exposure of the dental pulp to the oral cavity is the most obvious route of endodontic infection. Caries is the most common cause of pulpal exposure, but microorganisms may also reach the pulp via direct pulp exposure because of iatrogenic restorative procedures or trauma. The exposed pulp tissue develops direct contact with oral microorganisms from carious lesions, saliva, or plaque accumulated onto the exposure surface.

### Periodontal disease

Microorganisms in sub-gingival biofilms associated with periodontal disease could reach the pulp by the same pathways that intercanal microorganisms reach the periodontium and thereby could exert harmful effects on the pulp. Nevertheless, it has been demonstrated that although degenerative and inflammatory changes of different degree may occur in the pulp of teeth with associated periodontal disease, pulpal necrosis as a consequence of periodontal disease only develops if the periodontal pocket reach the apical foramen, lead to irreversible damage to the main blood vessels that penetrate through this foramen.

### Anachoresis

Anachoresis is a process by which microorganisms are transported in the blood or lymph to an area of tissue damage, where they leave the vessel, enter the damaged tissue, and establish an infection.

## Type of endodontic infections

Endodontic infection can be classified according to the anatomical location (intraradicular or extraradicular). Intraradicular infections can in turn be subdivided into three categories: primary, secondary, or persistent infection, established themselves within the root canal. The composition of microbiota may vary depending on the different forms of apical periodontitis.

### Intraradicular infection

Microorganisms colonizing the root canal system cause intraradicular infection, which can classified as primary, secondary, or persistent.

**Primary intraradicular infection**

Microorganisms that initially invade and colonize the necrotic pulp tissue cause primary intraradicular infection. It has also been referred to as initial infection or “virgin” infection.

Primary infections are characterized by a mixed consortium composed of 10 to 30 bacterial species and 10^3 to 10^8 bacterial cells per canal. The involved microorganisms is conspicuously dominated by anaerobic bacteria, but some facultative or microaerophillic species can also commonly found in primary intraradicular infections.

**Secondary Intraradicular infection**

Microorganisms that were not present in the primary infection but that were introduced into the root canal system at some time after professional intervention cause secondary intraradicular infection. The entry can be during treatment, between appointments, or even after root canal filling. Species involved can be oral or non-oral microorganisms, depending on the cause of infection. The main causes of microbial introduction in the canal during treatment include remnants of dental plaque, calculus, or caries on the tooth crown; leaking rubber dam; or contamination of endodontic instrument, irrigating solution, or other intra-canal medications. Microorganisms can enter the root canal system between appointments by loss or leakage of temporary restorative materials, by fracture of the tooth structure, and in teeth left open for drainage. Microorganisms can also penetrate the root canal system after root canal filling by loss or leakage of temporary or permanent restorative material, fracture of the tooth structure, recurrent decay that exposing the root canal filling material, or delay in placement of permanent restorations.

**Persistent intraradicular infection**

Microorganisms that can resist intracanal antimicrobial procedures and endure period of nutrient deprivation in prepared canal cause persistent intraradicular infection, this is also termed recurrent infection. Involved microorganisms are remnants of a primary or secondary infection. The microbiota associated with persistent infections is usually composed of fewer species than primary infections, and gram-positive facultative or anaerobic bacteria are predominant. Fungi can also be

found in frequencies significantly higher when compared with primary infections.

### Extraradicular infection

Extraradicular infection is characterized by microbial invasion of and proliferation in the inflamed periradicular tissues and is almost invariably a sequel to intraradicular infection. Extraradicular infection can be dependent on or independent of the intraradicular infection. The most common form of extraradicular infection dependent on the intraradicular infection is the acute apical abscess. The most common form of extraradicular infection that can be independent of the intraradicular infection is apical actinomycosis.

## The Endodontic Microbiota

Molecular technology has enabled the recognition of new putative pathogens that had never been previously found in endodontic infections. Moreover, many species that had already been considered as putative pathogens because of their frequencies as reported by culture-dependent methods have been found in similar or even in higher prevalence values by molecular approaches, strengthening their association with causation of apical periodontitis. As a consequence, the endodontic microbiota has been clearly redefined by molecular biology methods.

### Primary intraradicular infections

Sophisticated culture and molecular biology techniques have revealed the polymicrobial nature of endodontic infections, with a conspicuous dominance of obligate anaerobic bacteria in primary infections. Current evidence reveals that endodontic bacteria fall into 8 of the 13 phyla that have oral representatives, namely *Firmicutes, Bacteriodetes, Spirochaetes, Fosubacteria, Actinobacteria, Proteobacteria, Synergistes, and TM7.*

**Bacterial Genera Represented in Endodontic Infections**

| GRAM-NEGATIVE BACTERIA | | GRAM-POSITIVE BACTERIA | |
|---|---|---|---|
| **Anaerobes** | **Facultatives** | **Anaerobes** | **Facultatives** |
| **Rods** | | **Rods** | |
| *Dialister* | *Capnocytophaga* | *Actinomyces* | *Actinomyces* |
| *Porphyromonas* | *Eikenella* | *Pseudoramibacter* | *Corynebacterium* |
| *Tannerella* | *Haemophilus* | *Filifactor* | *Lactobacillus* |
| *Prevotella* | | *Eubacterium* | |
| *Fusobacterium* | | *Mogibacterium* | |
| *Campylobacter* | | *Propionibacterium* | |
| *Synergistes* | | *Eggerthella* | |
| *Catonella* | | *Olsenella* | |
| *Selenomonas* | | *Bifidobacterium* | |
| *Centipeda* | | *Slackia* | |
| | | *Atopobium* | |
| | | *Solobacterium* | |
| | | *Lactobacillus* | |
| **Cocci** | | **Cocci** | |
| *Veillonella* | *Neisseria* | *Micromonas* | *Streptococcus* |
| *Megasphaera* | | *Peptostreptococcus* | *Enterococcus* |
| | | *Finegoldia* | *Granulicatella* |
| | | *Peptoniphilus* | |
| | | *Anaerococcus* | |
| | | *Streptococcus* | |
| | | *Gemella* | |
| **Spirilla** | | | |
| *Treponema* | | | |

## Gram-negative Bacteria

Gram-negative bacteria appear to be the most common microorganisms in primary endodontic infections. Species belonging to several genera of gram-negative bacteria have been consistently found in primary infections associated with different forms of apical periodontitis, including abscesses. These genera include *Dialister (e.g., D. invisus* and *D. pneumosintes), Treponema (*e.g., *T. denticola* and *T. socranskii), Fusobacterium (e.g., F. nucleatum), Porphyromonas (*e.g., *P. endodontalis* and *P. gingivalis), Prevotella (*e.g., *P. intermedia, P. nigrescens* and *P. tannerae),* and *Tannerella* (e.g., *T. forsethia).*

## Gram-positive Bacteria

Even though anaerobic gram-negative bacteria are reported to be the most common microorganisms in primary infections, several gram-positive bacteria have also been frequently in endodontic mixed

consortium, some of them in prevalence values as high as the most commonly found gram-negative species. The genera of gram-positive bacteria often found in primary infections include *Pseudoramibacter* (e.g., *P. alactolyticus), Filifactor* (e.g., *F. alocis), Micromonas (*e.g., *M. micros), Peptostreptococcus* (e.g., *P. anaerobius), Streptococcus (*e.g., *S. anginosus group), Actinomyces (*e.g., *A israelii), Olsenella (*e.g., *O. uli),* and *propionibacterium* (e.g., *P. propionicum* and *P. acnes).*

**Persistent / Secondary Endodontic Infections**

Most root canal-treated teeth with persistent apical periodontitis lesion have been demonstrated to harbor an intraradicular infection. Microorganisms present in root canal-treated teeth can be "persisters" that survived the effects of intracanal disinfection procedures and were present in the canal at the root canal filling stage (persistent intraradicular infection) or they can have infected the canal after filling as a result of coronal leakage (secondary intraradicular infection).

**Available Nutrients**

In the root canal system, Bacteria can utilize the following as a source of nutrients: (1) the necrotic pulp tissue, (2) proteins and glycoproteins from tissue fluids and exudates that seep into the root canal system via apical and lateral foramens, (3) component of saliva that may coronally penetrate in the root canal, and (4) products of the metabolism of other Bacteria.