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COLLEGE OF DENTAL
MEDICINE

Endodontic Microbiology 1




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Objectives

- Terminologies: Endodontic Microbiology
- Objectives of Root Canal Treatment
- Factors affecting pulpal status
- Pathways to the pulp system
- Microorganisms Associated With Endodontic Disease



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Terminology

Colonization : the establishment of bacteria or other microorganism in a living host¹

Infection : damage the host and produce clinical signs and symptom

Pathogenicity :
The capacity of organisms to produce disease within a particular host

Virulence :
The degree of pathogenicity in a host under defined circumstance

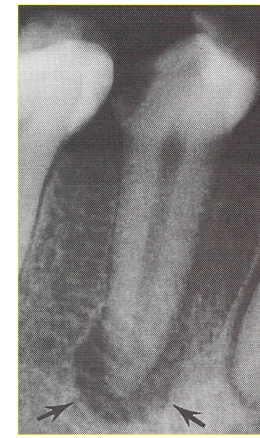
Biofilm :
sessile, multicellular microbial community characterized by cells that are firmly attached to a surface and trapped in self-produced matrix

Microbiota :
collective term for microorganisms and should replace terms such as flora and microflora

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Objectives of Endodontic Treatment

- The prevention and elimination of
Apical periodontitis
(Kakehashi et al., 1965; Moller et al., 1981;
Ramachandran Nair, 1987; Sundqvist, 1976;
Wittgow and Sabiston, 1975)



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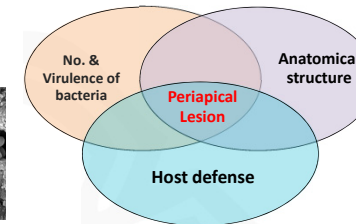
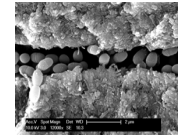
Biological basis



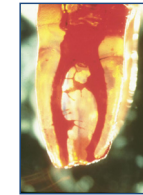
- Kakehashi 1965 –germ free rats
- The **presence or absence of microorganisms** is the major determinant in the healing of exposed rodent pulps.

Status of host defensive system

State of disease

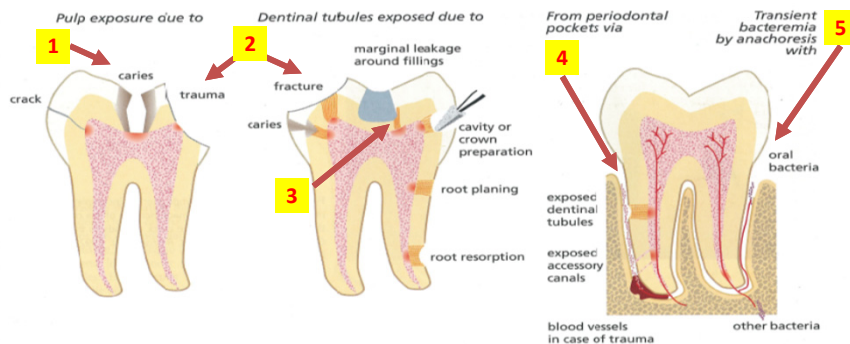


Spread of infection



- Normal **microbiota** may become "opportunistic pathogens."
- Opportunistic pathogens produce disease if they gain access to normally sterile dental pulp or peri-radicular tissues.

Pathways to the pulp system

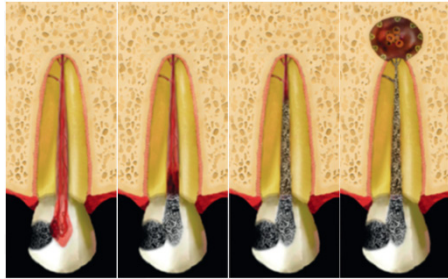


Dental Caries

- The **most common** pathway of microbes to the root canal system¹
- Intact tooth pulp space is protected by **enamel and dentin**
- As caries approaches the pulp, **reparative dentin** is laid down to avert exposure, but this rarely can prevent microbial entry without caries excavation.[#]



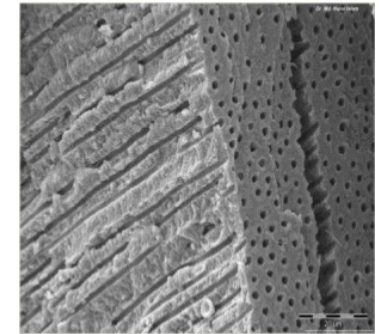
Dental Caries: Pulp response



- Bacteria and their by-products may have an **effect on the pulp** before direct exposure. If the caries is removed, the pulps can **undergo healing**.
- If the pulp is necrotic, "**dead tracts**" of empty dentinal tubules are rapidly penetrated.

Dental Caries: Dentinal tubules

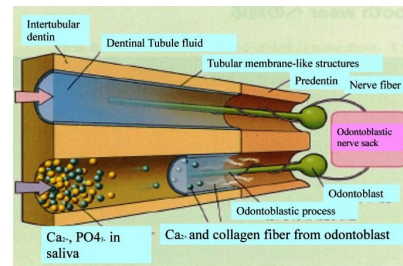
- 1 to 4 μm in diameter,
- Bacteria are less than 1 μm in diameter $\#$
- The protective cementum layer is missing or if it has been lost through trauma, the dentinal tubules may be exposed and may serve as a pathway for microbial invasion of the pulp space $\#$



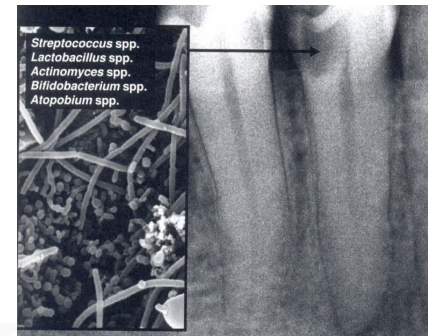
Dental Caries: Dentinal tubules

Bacterial movement is restricted by

1. Outflow of dentinal fluid,
2. Odontoblastic processes,
3. Mineralized crystals
4. Macromolecules, including immunoglobulins in the tubules $\#$



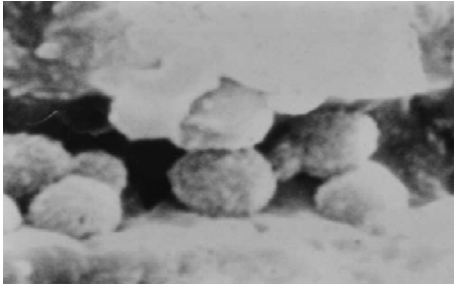
Dental Caries: bacteria



Facultative gram positive bacteria

And gram negative

Dental Caries: bacteria



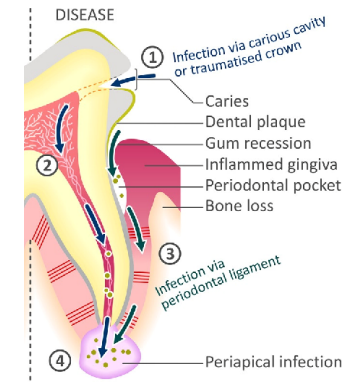
- **Coccal** forms of bacteria seen in the cross-section of a fractured dentinal tubule (X15000)

Periodontal Disease

- Accessory canal/Lateral canal
- Furcation canal
- Apical foramen
- Exposed dentinal tubule

Inflammation and local necrosis have been demonstrated in pulp adjacent to entry pathway.

Anerobic bacteria → Gram negative rod, spirochete



Periodontal Disease

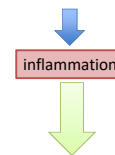


Periodontal lesion involve apical foramen

Guldenor et al 1985

Trauma

Pulp exposure due to trauma give access to oral bacteria, this will cause bacterial invasion to the pulp



Pulp necrosis

Kakehashi et al 1965



Trauma

Healthy exposed vital pulp, the penetration of tissue by bacteria is relative slow ≤ 2 mm./wk

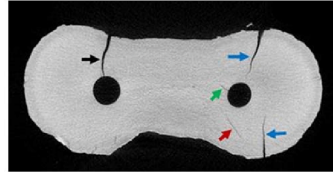
Cvek et al 1978

Laboratory experiments indicate that bacteria can enter through even minor crack in enamel or dentine.

Love et al 1996

Dentinal tubules exposed by tooth fracture during cavity preparation or marginal leakage are the potential pathway.

Bender & Seltzer 1959
Smulson & Sieraski 1989

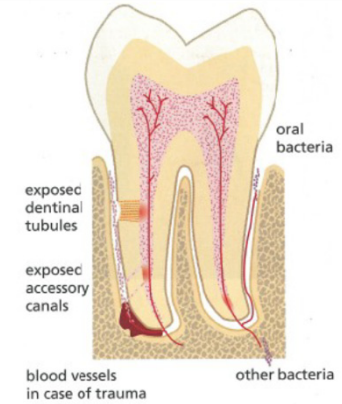


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Anachoresis

• It is the transportation of microbes through the blood or lymph to an area of inflammation.

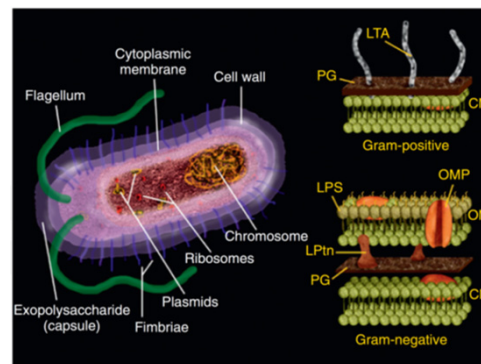
• Anachoresis could not demonstrated in humans.



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Bacterial Cell Structure

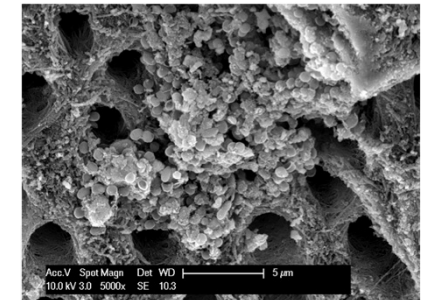
- Bacterial cell walls from gram-positive and gram-negative bacteria.
- CM, cytoplasmic membrane;
- LPS, lipopolysaccharide (endotoxin);
- LPtn, lipoproteins;
- LTA, lipoteichoic acid;
- OM, outer membrane;
- OMP, outer membrane protein;
- PG, peptidoglycan.



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Microorganisms Associated with Endodontic Disease

- Endodontic infections are polymicrobial
- The majority of bacteria isolated from an endodontic infection are anaerobic.



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Microorganisms Associated with Endodontic Disease

- **Strict anaerobes**: function at low oxidation-reduction potential and grow only in the absence of oxygen, but they vary in their sensitivity to oxygen#
- **Obligate anaerobic bacteria** lack the enzymes superoxide dismutase and catalase. Some species of bacteria are *microaerophilic*; they can grow in the presence of oxygen, but they derive most of their energy from anaerobic energy pathways#
- **Facultative anaerobic bacteria**: can grow in the presence or absence of oxygen1
- **Obligate aerobic bacteria**: have both superoxide dismutase and catalase and require oxygen for growth#

Microorganisms Associated with Endodontic Disease

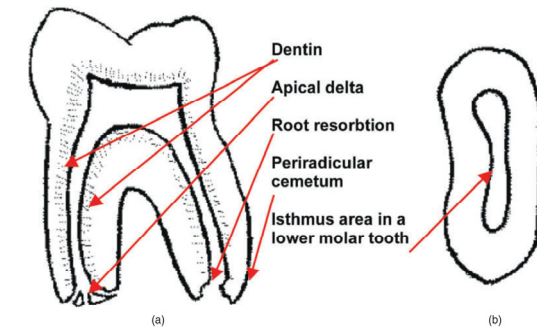


Fig. 4.6 Schematic drawing of a molar tooth indicating the location where special attention has to be taken for reaching bacteria at sampling: (a) longitudinal section; (b) horizontal or cross-sectional section of a lower molar tooth.

Microorganisms Associated with Endodontic Disease



Culturing

- Limited number of microorganisms that can culture in the media
- strongly bias and underestimate the diversity of microbial populations

Next-Generation Sequencing (NGS)

- Better and more accurate test of bacteria DNA
- identification of previously unknown human pathogens
- Discovery of a far broader diversity of the human microbiota associated with different human sites

Microorganisms Associated with Endodontic Disease

Table 3.3 Bacterial species commonly found in infected root canals.

Gram-positive cocci	Gram-positive rods	Gram-negative cocci	Gram-negative rods
<i>Streptococcus</i>	<i>Actinomyces</i>	<i>Capnocytophaga</i>	<i>Fusobacterium nucleatum</i>
<i>S. anginosus</i>	<i>A. israeli</i>	<i>C. ochracea</i>	<i>Prevotella</i>
<i>S. sanguinis</i>	<i>A. naeslundii</i>	<i>C. sputigena</i>	<i>P. intermedia</i>
<i>S. mitis</i>	<i>Eubacterium</i>	<i>Veillonella parvula</i>	<i>P. melaninogenica</i>
<i>S. mutans</i>	<i>E. alactolyticum</i>	<i>Campylobacter</i>	<i>P. denticola</i>
<i>Enterococcus faecalis</i>	<i>E. lentum</i>	<i>C. rectus</i>	<i>P. buccae</i>
<i>Peptostreptococcus</i>	<i>E. nodatum</i>	<i>C. curvus</i>	<i>P. buccalis</i>
<i>P. anaerobius</i>	<i>E. timidum</i>		<i>P. oralis</i>
<i>Parvimonas</i>	<i>Propionibacterium</i>		<i>Porphyromonas</i>
<i>P. micra</i>	<i>P. propionicum</i>		<i>P. gingivalis</i>
	<i>P. granulosum</i>		<i>P. endodontalis</i>
	<i>Lactobacillus</i> spp.		<i>Bacteroides gracilis</i>

Microorganisms Associated with Endodontic Disease

Primary Infection

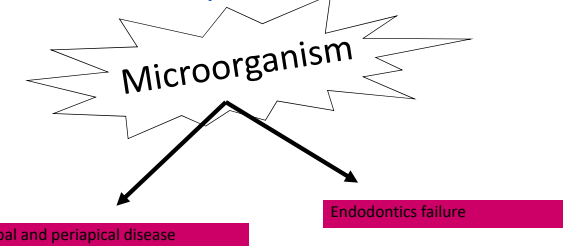
- Bacteroides,
- Propionomonas,
- Prevotella,
- Fusobacterium,
- Treponema,
- Peptostreptococcus,
- Eubacterium,
- Campylobacter species.

Secondary Infection

- Enterococci,
- Streptococci,
- Lactobacilli,
- Actinomyces
- Fungi (such as Candida)

Microorganisms Associated with Endodontic Disease

Polymicrobial



In 1890 W.D. Miller, the father of oral microbiology, was the first investigator to associate the presence of bacteria with pulpal disease¹.

Microorganisms Associated with Endodontic Disease

Polymicrobial

- The number of microorganisms detected in endodontic infections increased to a range of **three to 12 organisms** per infected root canal associated with an apical lesion.#
- The number of colony forming units -CFU is usually 10^2 to 10^8
- A **positive** correlation exists between the number of bacteria in an infected root canal and the size of periradicular radiolucencies.

Microorganisms Associated with Endodontic Disease

- **No** absolute correlation has been made between any species of bacteria and the **severity** of endodontic infections.
- This is probably related to the polymicrobial nature of endodontic infections and the relationship between bacteria or virulence factors that increase the overall pathogenic effect.
- Teeth that had asymptomatic, chronic inflammatory lesions, bacteria could not be identified beyond the root apex.

Microorganisms Associated with Endodontic Disease

- Polymicrobial infections spread from the root canal to the contiguous periradicular tissues.
- Endodontic abscesses are mixed infections with several strains of bacteria.
- Periapical granulomas **prevent** the spread of infection to surrounding tissues. Thus "a granuloma is not an area in which bacteria live, but in which they are destroyed".

Microorganisms Associated with Endodontic Disease

- **Intact teeth with necrotic pulp:** strict anaerobes more than **90%** of the bacteria
- **The apical 5 mm of carious exposed teeth:** **67%** of the bacteria were strict anaerobes
- #
- **Gram-negative** bacteria, especially species of ***Porphyromonas* and *Prevotella*** that are dark black pigmented, have been associated with endodontic infections.#

Microorganisms Associated with Endodontic Disease

Failed Endodontic Treatment#

- **Complete periapical healing occurred in:**
94% of roots with negative culture
68% of cases with positive culture
- ***Enterococcus faecalis*** has been the predominant microbe in canals undergoing retreatment
- ***E. faecalis*** was found in **77%** of cases, confirming that this microbe is the most prevalent species in failed endodontic treatment.#

Thank You !

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