Chlorhexidine:
A Multi-Functional Antimicrobial Drug
A Peer-Reviewed Publication
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Educational Objectives
Upon completion of this course, the clinician will be able to do the following:
1. Explain the mechanism of action of chlorhexidine gluconate.
2. Identify the unique property that allows for a prolonged effect.
3. Describe the clinical indications for use.
4. Understand the mechanism by which chlorhexidine may cause extrinsic stain and the recommended home care strategies to reduce its occurrence.
5. Apply the dosage and guidelines for the clinical use of chlorhexidine gluconate.

Abstract
Chlorhexidine gluconate is an effective bactericidal agent and broad-spectrum antimicrobial drug. It has been extensively researched and is the “gold standard” antimicrobial in oral hygiene. Chlorhexidine is useful in many clinical disciplines including periodontics, endodontics, oral surgery and operative dentistry.

Introduction
Chlorhexidine gluconate (chlorhexidine) is a broad-spectrum antimicrobial drug. Acting as an antiseptic, it is an effective bactericidal agent against all categories of microbes, including bacteria, yeast, and viruses.

Chlorhexidine molecules are positively charged (cations) and most bacteria and surface structures in the oral cavity, including the surfaces of teeth and mucous membranes, are negatively charged (anions). In accordance with the principle that opposite charges attract, chlorhexidine binds strongly to all these surface structures.

When chlorhexidine binds to microbial cell walls it induces changes, damaging the surface structure, leading to an osmotic imbalance with consequent precipitation of cytoplasm causing cell death. The substantivity of chlorhexidine enhances this bactericidal effect, which allows for the retention of chlorhexidine in the oral cavity and a prolonged residual antimicrobial effect for up to 12 hours or longer depending on the dosage and form.

Chlorhexidine is safe and has an inherent advantage over antibiotics by not producing resistant microorganisms. As a result chlorhexidine can be used repeatedly and over long periods of time. Furthermore, it destroys all categories of microbes, not just bacteria, and there is little risk for the development of opportunistic infections.

As with many FDA approved drugs, the use of chlorhexidine does have known disadvantages; however, these disadvantages are a small trade off compared to the many advantages and are reversible once the use of chlorhexidine is discontinued.

Chlorhexidine was first used as a mouthrinse as an adjunct to conventional non-surgical periodontal therapy in Europe in the early 1970s. It received FDA approval in 1986 under the brand name PERIDEX® (Zila Pharmaceuticals) based on studies showing that it reduced gingivitis by up to 41%. Soon after, PERIDEX®, was the first mouthrinse to receive the ADA Seal of Acceptance. Generic rinses have been available since 1994 and are available from many different companies. In order to qualify as a generic, the medication must prove to have 80-120% of the bioavailability of the name brand to be considered bioequivalent. To date, there have been no published equivalency studies between the brand PERIDEX® and any generic rinses.

Chlorhexidine has proven efficacy as a broad-spectrum antimicrobial for reducing supragingival plaque.

In 1997, chlorhexidine was introduced in a locally applied, controlled-release gelatin chip (PerioChip®, OMNII Oral Pharmaceuticals) as a treatment to reduce pocket depths in patients with adult periodontitis.

Since then there have been many off-label uses arising from the desire to effectively reduce microbial pathogens to enhance treatment results. Some of the uses will be reviewed so that clinicians can make an informed decision about incorporating chlorhexidine into their treatment protocols.

Periodontics
Gingivitis
Chlorhexidine is recognized as the gold standard antimicrobial in oral hygiene. When chlorhexidine gluconate 0.12% rinse is used in between professional dental visits gingival healing is significantly improved. Rinses containing chlorhexidine are intended for any patient presenting with redness and swelling of the gingivae, including gingival bleeding upon probing. However, many practitioners reserve chlorhexidine for their most
severe cases of gingivitis due to the potential for extrinsic staining of the teeth. The extrinsic staining, which will be discussed further, is easily remedied so the advantages to the patient far outweigh any adverse event.

The recommended protocol for rinsing with chlorhexidine is 15 mL for 30 seconds twice a day. Patients will experience significant reductions in plaque, gingivitis and bleeding sites. The extrinsic staining, which will be discussed further, is easily remedied so the advantages to the patient far outweigh any adverse event.

Gingival irrigation to reduce oral bacteria, both supra- and subgingival, has been used as both a professionally delivered treatment and an adjunct to homecare. The goal of supragingival irrigation is to flush away bacteria to reduce the development of gingivitis, or to decrease the patient’s existing gingivitis. Supragingival irrigation is most beneficial in patients where interdental plaque control is ineffective. Subgingival irrigation aims to reduce bacteria within periodontal pockets by delivering the solution directly into the pocket either by use of a 1) syringe; 2) jet irrigator with a cannula; and/or 3) an ultrasonic unit. The goal is to treat periodontitis or prevent it from occurring.

Chlorhexidine, although not alone, is the most studied drug. As a medicament, the substantive property makes it an ideal choice for irrigation. However, studies are inconclusive. Some suggest that subgingival irrigation is better for improved periodontal results. Others say patients that did not receive subgingival irrigation received similar results. This might be due to the fact that, although chlorhexidine is retained in the pocket it might not be retained long enough. Nevertheless, there is data to suggest that irrigation with a high level of chlorhexidine may enhance scaling and root planing; but it seems continual therapy is more appropriate than the administration of one in-office irrigation treatment.

Recommendations would be to either have patients follow-up with a regular at-home irrigation regimen, or to use a professionally administered locally applied alternative where the bactericidal level of chlorhexidine in the pocket is more predictable. For an at-home protocol it would be advisable for patients to continue with subgingival irrigation for at least 28 days to be followed by a 2–3 month reevaluation appointment after the initial scaling and root planing.

**Periodontitis**

Chlorhexidine has also been used with great success in periodontal therapy in the form of a subgingival, time released, local delivery system. The chlorhexidine chip (2.5 mg) is a small gelatin chip inserted into periodontal pockets >5 mm deep. The chip will dissolve and release chlorhexidine over 7–10 days and eradicate pathogens (e.g. Porphyromonas gingivalis) commonly identified in the subgingival biofilm of patients with periodontal disease and deep subgingival pockets.

Porphyromonas gingivalis (Pg) is often difficult to eliminate especially when implicated in periodontal disease. Like many other pathogenic bacteria associated with periodontal disease, Pg becomes embedded in biofilm making it resistant to higher concentrations of antimicrobial drugs. Chlorhexidine has demonstrated an increased efficacy in eliminating Pg embedded in biofilm than comparable antimicrobial agents. By incorporating chlorhexidine into treatment protocols, this important periodontal pathogen can be significantly reduced thus promoting resolution and healing.

The simplicity of the chlorhexidine chip has increased in recent years with the introduction of a non-refrigerated chip that can be placed using a standard cotton plier. Research has found that when the chlorhexidine chip was used as an adjunct to scaling and root planing, patients were 2–3 times more likely to have pocket depth reductions of 2 mm or more when compared to those treated with a placebo chip. Patients can also be treated, as needed, as a part of a long-term periodontal maintenance program. In one study, patients had the chlorhexidine chip inserted into periodontal pockets when they measured 5 mm deep or more. Results revealed that 91.8% of sites either improved (73%) or stabilized (18.8%) over a two-year period. The advantages of incorporating chlorhexidine into non-surgical periodontal therapy should not be underestimated. It is a simple and inexpensive addition to the traditional protocols and has yielded significant benefits for patients by enhancing resolution and recovery. Clinical research also supports the use of chlorhexidine prior to surgical procedures as part of initial therapy. In this case, the goal is less a measure of pocket depth and
more a way to reduce the bacterial challenge within the surgical area.

**Regenerative periodontal surgery**

One of the most significant threats to success in bone regenerative procedures is local infection and inflammation. Disinfecting the surgical site with chlorhexidine chips has been shown to increase the chance of success in regenerative periodontal procedures involving bone grafts by resulting in significant gains in bone height and bone mass over time. They should be used during initial therapy, one week prior to regenerative surgery, and as a part of the maintenance program, in pockets ≥5 mm deep. Incorporating the use of chlorhexidine chips into regenerative procedures is relatively simple, inexpensive and expected to yield significant improvements in healing.

**Preprocedural Rinsing**

The oral cavity is largely contaminated with viruses and bacteria. Sources of these microorganisms are: dental plaque, saliva, the nose, throat, and respiratory tract. Dental procedures that utilize ultrasonic scalers, dental handpieces, air polishers and air abrasion units have the potential to create aerosolized material that could include: supra- and subgingival plaque organisms, blood, and viruses including the influenza virus and the common cold virus.8

There is no scientific evidence that supports preprocedural rinsing as a defensive measure to reduce infections of the dental office staff by patients. However, studies have shown that using an antimicrobial rinse, such as chlorhexidine, can reduce the number of organisms in aerosols created during routine dental treatment.9 This may also be beneficial for patients who are at higher risk for developing bacterial endocarditis.

Preprocedural rinsing has, however, been proven beneficial if done prior to oral surgery procedures.

**Oral Surgery**

One common complication of third molar extractions is alveolar osteitis (i.e., ‘dry socket’) which may present with a necrotic, lysed or disintegrating blood clot accompanied by a fetid odor, unpleasant taste and severe or even incapacitating pain. Pain may radiate to the ear or the entire side of the face with the onset usually 2–4 days post-operative. The incidence varies but may be as high as 30%, especially for impacted third molars.

The etiology of alveolar osteitis is largely unknown. One theory is that the blood clot fails to form after the extraction. A second theory is that the blood clot forms but disintegrates or undergoes fibrinolysis shortly after it forms. A bacterial source of fibrinolytic agents has been theorized.10

Rinsing preoperatively with a 0.12% chlorhexidine gluconate solution resulted in a 97% decrease in the intraoral aerobic bacterial load that persisted for at least 1 hour.11 Rinsing with chlorhexidine for one week prior to surgical third molar extractions and for one week post-operatively resulted in a significant reduction in alveolar osteitis.12

One of the most effective protocols proposed to decrease the incidence of alveolar osteitis involves the use of a pre-operative and/or post-operative rinse with chlorhexidine.13 The most frequent protocol is for the patient to rinse with 15 mL of chlorhexidine for 30 seconds twice daily.

A decrease in bacterial load can also benefit surgical cases where implants are being placed. Infection can lead to implant failure.

Meticulous attention to infection control protocol and eliminating potential sources of infection are critical to enhance the successful osseointegration of implants. In addition to implementing stringent infection control measures throughout implant procedures, rinsing with chlorhexidine will significantly reduce the opportunity for microbial infections and increase the potential for successful osseointegration.14

In cases where the area around an implant becomes infected and results in perimplantitis, the use of chlorhexidine irrigants in conjunction with mechanical debridement may produce significant improvements in resolution and healing.15

When implants are placed, bone may be harvested for use in simultaneous bone augmentation procedures to insert around implants with gaps in the bone-implant interface. Rinsing preoperatively with chlorhexidine results in significantly fewer bacteria in harvested bone, consequently yielding a decreased chance of post-operative infections.16

When used in a regular program of routine implant maintenance with routinely scheduled recalls, rinsing with chlorhexidine can be expected to produce significant improvements in periodontal health over time. Improvements can be expected in Gingival Index, Plaque Index, Bleeding Index and Calculus Index.17

The improvement in the above indices may also have a beneficial effect on caries control as well as on the control of oral malodor.

**Preventive Dentistry**

**Caries**

There are a number of theories concerning the development and progression of dental caries. According to the Specific Plaque Hypothesis, only a limited number of bacteria found in dental plaque can produce dental caries.18 The most prominent among these odonto-
pathogenic bacteria are the Lactobacilli and the mutans streptococci.²⁹,³⁰ Mutans streptococci represent a group of closely related bacterial species that are the primary species that initiate enamel caries. Therefore, patients with low mutans streptococci population levels in their oral cavity generally have low caries activity and patients with high mutans streptococci population levels generally have high caries activity.²¹ Lactobacilli are the primary causative species of dentinal caries and generally colonize after mutans streptococci have exposed the dentinoenamel interface.

Caries is a communicable disease and is a bacterial infection of the enamel, dentin and cementum. Infants are not born with mutans streptococci in their oral cavity.²² Mutans streptococci are transmitted from the mother, father or care giver to infants and toddlers, generally between 19 to 28 months of age, with 83% of children infected by the age of four.²³,²⁴ Children with demonstrable levels of mutans streptococci develop carious lesions. Children without demonstrable levels of mutans streptococci do not. Prevention of transmission of mutans streptococci from caregiver to child for the reduction of dental caries is the subject of many current caries trials and public health dental programs.

**Chlorhexidine is a very potent bactericidal agent for mutans streptococci, the most significant group of bacterium associated with caries.**²⁵ Chlorhexidine molecules adhere to the surfaces of mutans streptococci and produce cell death.

Under some circumstances with professional intervention and intensive home care, mutans streptococci can be eradicated from the oral cavity. In one protocol, patients had their teeth professionally cleaned every day for ten days. Following the dental prophylaxis, patients had 1.0% chlorhexidine applied twice in custom trays. Patients brushed three times a day and applied chlorhexidine 0.2% twice a day — in the morning and before bed. Patients rinsed with 0.2% chlorhexidine after lunch.

At four months, three out of seven subjects in the study demonstrated no detectable level of mutans streptococci.²⁶ However three of the subjects still had detectable levels of mutans streptococci. These three subjects also had deep periodontal pockets and it is possible that mutans streptococci might have found refuge in them and thus eluded the bactericidal effects of chlorhexidine.

*The results of a three-year randomized clinical trial to provide caries management through risk assessment were presented in March 2005 by Dr. John Featherstone et al., from the University of California-San Francisco, during the International Association of Dental Research Meeting. In the study caries active subjects (N=230) were assigned either to a “conventional care” group or a “preventive intervention” group. Treatment in the conventional care group included restoration of any cavitated lesions and oral health instructions. The preventive intervention group were also restored and provided oral health instructions but then also received both a 0.12% chlorhexidine gluconate (CHX) rinse and a 0.05% NaF (F) daily use rinse through the study duration. The study found that “combining CHX to reduce the bacterial challenge and F to enhance remineralization successfully and significantly reduced caries risk by about three times and suggested a reduced caries risk increment.”²⁷*

For patients with a high risk of caries, chlorhexidine rinses can be successfully used to reduce the number of odontopathogenic bacteria. This should be integrated into an intensive home care program to maintain the optimum level of oral hygiene.

Meticulous home care can also benefit those troubled by oral malodor.

**Oral Malodor**

Oral malodor (i.e., breath malodor, bad breath, halitosis, etc.) afflicts a significant number of people in the United States. For many, the problem is significant and impacts daily life and social interactions. There are many, so-called, quick fixes in the form of lozenges, rinses, gum, etc, for purchase over-the-counter in pharmacies and health food stores. Awareness of this problem and the stigma associated with it has created a huge market in health care.

The etiology of breath malodor varies, but originates about 87% of the time in the oral cavity.²⁸,²⁹ It is caused most frequently by bacterial products, which produce volatile sulphur compounds with characteristic foul odor components. Many of these bacteria are embedded in periodontal pockets, plaque and calculus making them difficult to access and eradicate.

Oral malodor is associated with periodontal disease, deep periodontal pockets, and an increase in the amount of calculus, a high plaque index and poor oral hygiene.³⁰ Anaerobic bacteria residing on the dorso-posterior surface of the tongue is also an important source of volatile sulphur compounds and tongue cleaning may be required to reduce this population of bacteria in this area.³¹

Many treatment protocols have been proposed for reducing or eliminating bad breath. One of the most effective treatments developed thus far is for the patient to rinse with chlorhexidine.³² It is probable that the decrease in malodor observed when patients rinse with chlorhexidine is due, at least in part, to the reduction in the plaque index as well as the reduction in gingival inflammation resulting in fewer bacteria capable of generating volatile sulphur compounds. Rinsing with
chlorhexidine twice daily (i.e., once in the morning and once at night) is sufficient to produce a significant decrease in bacterium that produces volatile sulphur compounds thus decreasing oral malodor.33

Another area where chlorhexidine has found a use is in endodontics.

Endodontics
In endodontic therapy, chlorhexidine is now widely used as an intracanal irrigant or as an intracanal medicament. Its wide antimicrobial spectrum offers efficacy, while ease in delivery and reasonable price make it a practical choice. Unlike other intracanal irrigants and medicaments, it has no tissue toxicity.

Most root canal infections involve a mixture of aerobic and anaerobic bacteria, with the anaerobic bacteria producing the dominant pathological features of infection and inflammation. The primary objective in root canal treatment is the removal of infected pulpal tissue and infectious microbial pathogens.

This is accomplished with mechanical debridement via instrumentation and intracanal irrigants. Mechanical instrumentation with files and reamers widens the root canal space and removes the bulk of the pulp tissue and pathogenic microbial agents. However some fragments of tissue and pathogenic microorganisms will remain even after the most stringent or aggressive mechanical instrumentation of the canal space.

Two significant anaerobic pathogens isolated from root canal infections are Enterococcus faecalis and Actinomyces israelii. Both can penetrate into the dentinal tubules, making them difficult to eradicate. Enterococcus faecalis can penetrate 400 microns with Actinomyces israelii penetrating deeply into dental tubules as well.34,35 For this reason, infectious microbial agents can be eliminated only after the introduction of appropriate intracanal irrigants.

Irrigants are introduced into the root canal space to dissolve tissue and kill pathogenic bacteria that have not been eliminated by conventional mechanical instrumentation. The most widely used intracanal irrigants are sodium hypochlorite, iodine potassium iodide, hydrogen peroxide, alcohol and chlorhexidine. Each of the irrigants possesses its own set of particular attributes.

Sodium hypochlorite is commonly used because it is the most effective tissue solvent, has excellent microbicidal properties and is inexpensive. One disadvantage of sodium hypochlorite is that it can be harsh on the periapical tissues, causing destruction of the PDL at and around the apices if extruded through the apex. This can be painful to the patient, although there are certain syringes and techniques that can be used to minimize this occurrence.

Most cases of root canal failure that have been cultured demonstrate high levels of anaerobic bacteria, notably Enterococcus faecalis and Actinomyces israelii. Actinomyces israelii is part of the normal oral flora and has been isolated from dental plaque, carious dentin and periodontal pockets; however, in certain circumstances it can cause an infection.36 These microorganisms are very susceptible to chlorhexidine.

Chlorhexidine 0.12% solution is an effective antimicrobial agent when delivered to the root canal space as an intracanal irrigant. It is able to penetrate deeply into the dentinal tubules and kill the pathogenic bacteria.

Table 1. Intracanal Irrigants

| Sodium Hypochlorite | Chlorhexidine Gluconate | Hydrogen Peroxide | Alcohol | Saline | Iodine Potassium Iodide |

There has been a major paradigm shift in endodontic therapy protocols from the traditional multiple-visit approach to initiating and completing endodontic therapy in a single-visit whenever indicated and whenever possible. However, in certain instances a multiple-visit approach is still warranted. It is thought that, during the interim period between multiple visits, pathogenic microorganisms are able to repopulate in the root canal space.37 Therefore, the importance of eliminating pathogenic bacteria from infected root canals should not be underestimated. Actinomyces
Actinomyces israelii can migrate into the general circulation during or after root canal treatment. It can also migrate out of the infected root canal into the periapical tissue where it can produce an abscess. Actinomyces israelii is an opportunistic pathogen and can infect extraction sockets, periodontal surgery sites, areas of trauma and other susceptible portals of entry.

A number of intracanal medicaments have been used to prevent this rebound of pathogenic microorganisms and the most frequently used are listed in Table 2. Some possess undesirable properties. Formocresol and Camphorated Monochlorophenol have exhibited some tissue toxicity. Iodine Potassium Iodide is active for only a short period of time, poisonous if ingested and provokes an allergic reaction in some patients. Calcium Hydroxide requires prolonged application in order to be maximally effective as an antimicrobial agent and is not always successful in eliminating pathogenic bacteria. Chlorhexidine, when introduced into the root canal space as an intracanal medicament, is the only medicament that can completely eliminate Actinomyces israelii and is far more biocompatible than the other intracanal medicaments. It is also inexpensive, easy to deliver and readily removed.

Table 2. Intracanal Medicaments

| Formocresol | Camphorated Monochlorophenol (CMCP) | Calcium Hydroxide | Calcium Hydroxide with CMCP | Chlorhexidine Gluconate | Iodine Potassium Iodide |

Known Side Effects
There are many benefits to incorporating chlorhexidine into treatment protocols along with some precautions. The most common side effects are altered taste perception, an increase in calculus formation, and an increase in staining of the teeth. In addition, anyone with a known hypersensitivity to it should not be prescribed chlorhexidine.

Staining
Two theories currently exist to explain the staining mechanism of chlorhexidine. One theory suggests that chlorhexidine molecules interact with chromogens present in food and beverages and the resultant precipitate produces much of the tooth staining. The second theory proposes that a series of chemical reactions between sugars and amino acids, called the maillard or non-enzymatic browning reaction, causes compounds to form as products of this reaction. This is also seen in the browning of foods high in carbohydrates and sugars, such as apples and potatoes. Not all patients will experience a visually significant increase in tooth staining. In clinical testing, 56% of oral rinse users exhibited a measurable increase in facial anterior stain of the teeth, compared to 35% of control users after 6 months.

Chlorhexidine stain, being extrinsic, is easily removed from the teeth with a variety of techniques and materials. One very effective technique is to use an electric or battery powered toothbrush, oscillating or rotating, which can be expected to decrease stain by 75% after 4 weeks of use. However, manual tooth brushing will also remove chlorhexidine stain, although not as rapidly or efficiently. Another very effective technique for chlorhexidine stain removal is to use a whitening dentifrice. These are inexpensive and can be obtained over the counter in any pharmacy. An advantage of using a whitening dentifrice simultaneously with the implementation of chlorhexidine rinsing is that the amount of acquired stain will be reduced and easier to remove. Additional studies have recommended chewing gum as a way to help reduce the potential for staining.

Educating patients on maintaining optimum oral hygiene will greatly reduce the possibility of chlorhexidine stain, since stain will collect more readily in the presence of plaque biofilm.

Conclusion
Recognizing the clinical application of the broad-spectrum antimicrobial chlorhexidine gluconate and incorporating it into your specific clinical practice setting is an appropriate and effective mode of action. The varied and effective applications of chlorhexidine make it a viable option for use in all dental settings and within a variety of dental procedures and pre-procedures with very few undesirable side effects.

Glossary of Terms

Antiseptic: A chemical that destroys or inhibits the growth of microorganisms and is sufficiently non-toxic for superficial application to the skin and mucous membranes. Can be used internally to treat infections of the intestine and bladder.

Osmosis: The flow of a solvent by diffusion through a semipermeable membrane from a more concentrated solution to a less concentrated one, until the concentrations are equalized.

Substantivity: The property of an antiseptic or disinfectant that makes it effective for a prolonged period of time following its application.
References

37. Periex Package Insert
Author Profile

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Dr. Kaplowitz retired from the military after serving as Chief Dental Officer of The U.S. Coast Guard. He is a graduate of the New York University College of Dentistry and is a Diplomate of the American Board of General Dentistry. He has published widely on dental materials and clinical techniques. He is editor of Osseonews.com and is in private practice in York, Pennsylvania.

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Marilyn Cortell has extensive experience as a dental hygiene educator and national lecturer. Currently she is a full time Assistant Professor at New York City College of Technology and an Adjunct Clinical Associate Professor at New York University. She is a member of The National Speakers Association, American Academy of Dental Hygiene and The American Dental Hygienist’s Association. Along with serving both on the editorial board of RDH Magazine and a consultant member to the North East Regional Board of Dental Examiners (NERB), Marilyn has contributed to three prominent widely distributed dental hygiene textbooks and is currently serving as an appointed member of the ADHA Council on Public Relations.

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Questions

1. Chlorhexidine has a _____ charge.
   a. positive
   b. negative
   c. neutral
   d. None of the above

2. The surfaces of the teeth have a _______ charge.
   a. positive
   b. negative
   c. neutral
   d. None of the above

3. The cell walls of microorganisms have a _______ charge.
   a. positive
   b. negative
   c. neutral
   d. None of the above

4. Side effects of chlorhexidine that some patients experience are:
   a. bitter taste
   b. extrinsic staining of teeth
   c. increased rate of formation of calculus
   d. All of the above

5. Chlorhexidine is not an antibiotic. It is an _______.
   a. antigen
   b. antidote
   c. antiseptic
   d. anticon

6. The unique property of substantivity allows for the _______.
   a. short action of chlorhexidine
   b. prolonged effect of chlorhexidine
   c. buffering effect of chlorhexidine
   d. bactericidal effect of chlorhexidine

7. In order for a generic drug to be approved by the FDA, the drug must _______.
   a. work 80% of the time
   b. be 20% as effective
   c. be no more than 80% effective
   d. be at least 80% bioequivalent

8. The advantages of using chlorhexidine as an intracanal irrigant in endodontic therapy include:
   a. broad spectrum activity
   b. ease of delivery
   c. low tissue toxicity
   d. All of the above

9. One of the objectives of using chlorhexidine as an intracanal medicament between visits is to _______.
   a. prevent rebound of pathogenic microorganisms
   b. fill the root canal space
   c. seal the root canal space
   d. dissolve residual tissue

10. Mechanical debridement of the root canal space does not remove all pathogenic microorganisms because
    a. the microorganisms adhere tenaciously to the root canal walls
    b. the pathogenic microorganisms in the root canal space penetrate deeply into the dentinal tubules
    c. the pathogenic microorganisms are resistant to mechanical debridement
    d. mechanical debridement is ineffective at removing microorganisms

11. Enterococcus faecalis can penetrate dentinal tubules up to _______.
    a. 50 microns
    b. 200 microns
    c. 400 microns
    d. 1,000 microns

12. In endodontic therapy, chlorhexidine is effective against _______.
    a. enterococcus faecalis
    b. actinomyces israeli
    c. most bacteria
    d. All of the above

13. One advantage sodium hypochlorite has, as an intracanal irrigant compared to chlorhexidine is that _______.
    a. it is less expensive
    b. it has a recognizable odor
    c. it is easier to deliver
    d. it dissolves soft tissue very well

14. Caries is a _______.
    a. hereditary disease
    b. communicable disease
    c. reactive disease
    d. immunologic disease

15. The most prevalent bacteria associated with caries is _______.
    a. porphyromonas gingivalis
    b. prevotella intermedia
    c. mutans streptococci
    d. treponema denticola

16. The signs and symptoms of alveolar osteitis include _______.
    a. pain radiating to the ear
    b. onset 2-4 days post-operatively
    c. oral malodor
    d. All of the above

17. Rinsing with chlorhexidine before or after third molar extractions can result in an _______.
    a. increased chance of alveolar osteitis
    b. decreased chance of alveolar osteitis
    c. increased chance of salivary flow compromise
    d. decreased chance of salivary flow compromise

18. Patients with an increased chance of developing bacterial endocarditis should _______.
    a. rinse once post-operatively with chlorhexidine
    b. rinse twice post-operatively with chlorhexidine
    c. rinse pre-operatively with chlorhexidine
    d. not rinse with chlorhexidine

19. Chlorhexidine rinse when used in conjunction with routine scaling and root planing can be expected to produce _______.
    a. a significant reduction in pocket depths
    b. a significant reduction in bleeding on probing
    c. none of the above
    d. All of the above

20. Chlorhexidine chips can be _______.
    a. inserted into pockets ≥5 mm deep
    b. placed with a standard cotton plier
    c. used repeatedly as a part of a long-term periodontal maintenance program
    d. All of the above

21. Chlorhexidine chips can be used in regenerative periodontal therapy to _______.
    a. facilitate graft placement
    b. facilitate membrane removal
    c. reduce the incidence of infection and inflammation
    d. All of the above

22. Porphyromonas gingivalis is often difficult to eliminate because _______.
    a. it is very resilient
    b. it reproduces rapidly
    c. it develops resistance to chlorhexidine
    d. it is often embedded in biofilm

23. Preprocedural rinsing may be a good idea because aerosolized material may include: supra- and subgingival plaque organisms, blood, and viruses including influenza and the common cold.
    a. True
    b. False

24. Oral malodor is most often caused by _______.
    a. hepatic dysfunction
    b. bacteria in the oral cavity
    c. ketosis
    d. alkalosis

25. Oral malodor is frequently associated with _______.
    a. periodontal disease
    b. increased amounts of calculus
    c. high plaque index
    d. All of the above

26. The most effective of the treatments for oral malodor is _______.
    a. lozenges
    b. fragrant mouth sprays
    c. anti-bacterial gels
    d. rinses with chlorhexidine

27. Chlorhexidine staining is largely due to the reaction of chlorhexidine with _______.
    a. bisguanides
    b. dication
    c. chromogens
    d. dichromides

28. Chlorhexidine stain is _______.
    a. intrinsic
    b. extrinsic
    c. internal
    d. covalently bound

29. Chlorhexidine stain is _______.
    a. difficult to remove
    b. easy to remove
    c. rarely noticeable
    d. a myth

30. To reduce the occurrence of staining, patients rinsing with chlorhexidine can _______.
    a. brush their teeth with a powered toothbrush
    b. chew gum
    c. use a whitening toothpaste
    d. All of the above
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Requirements for successful completion of the course and to obtain dental continuing education credits: 1) Read the entire course. 2) Complete all information above. 3) Complete answer sheets in either pen or pencil. 4) Mark only one answer for each question. 5) A score of 70% on this test will earn you 4 CE credits. 6) Complete the Course Evaluation below. 7) Make check payable to PennWell Corp.

Educational Objectives

1. Explain the mechanism of action of chlorhexidine gluconate.
2. Identify the unique property that allows for a prolonged effect.
3. Describe the clinical indications for the use of chlorhexidine gluconate.
4. Understand the mechanism by which chlorhexidine may cause extrinsic stain in some patients and the recommended patient home care strategies to reduce its occurrence.
5. Apply the dosage and guidelines for the clinical use of chlorhexidine gluconate in periodontics, endodontics, oral surgery, operative dentistry and preventive dentistry.

Course Evaluation

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

1. Were the individual course objectives met?
   - Objective #1: Yes No
   - Objective #2: Yes No
   - Objective #3: Yes No

2. To what extent were the course objectives accomplished overall?  S  4  3  2  1  0
3. Please rate your personal mastery of the course objectives. S  4  3  2  1  0
4. How would you rate the objectives and educational methods? S  5  4  3  2  1  0
5. How do you rate the author’s grasp of the topic? S  5  4  3  2  1  0
6. Please rate the instructor’s effectiveness. S  5  4  3  2  1  0
7. Was the overall administration of the course effective? S  5  4  3  2  1  0
8. Do you feel that the references were adequate? Yes No
9. Would you participate in a similar program on a different topic? Yes No
10. If any of the continuing education questions were unclear or ambiguous, please list them.
11. Was there any subject matter you found confusing? Please describe.
12. What additional continuing dental education topics would you like to see?

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