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Plaque Control: Efficacy of Local Antimicrobials and Oral Hygiene Instructions

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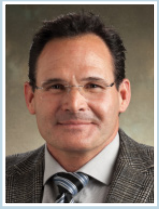
About the speaker



A/Prof. Axel Spahr

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Axel Spahr is Head of Periodontics at the Sydney Dental Hospital and Head of the Discipline of Periodontics at the University of Sydney.

Axel is the former Head of Periodontics at the University of Ulm in Germany and has worked at various international universities and research facilities. He has additional training in microbiology, molecular biology, extensive experience in basic science research, animal research and clinical research. A/Prof. Spahr's research interest includes periodontal regeneration, bone regeneration, periodontitis and systemic diseases as well as antimicrobial therapy. He has lead large externally funded research projects and is collaborating with leading international research groups and companies in the field of periodontology, implantology and bone regeneration. He is author of numerous publications in international peer-reviewed dental and medical journals and has presented his work on professional conferences worldwide. A/Prof Spahr is a board registered periodontal specialist and is the current President of the Periodontal Research Group of the International Association of Dental Research (IADR).

This review is a summary of a presentation, "*Plaque control, efficacy of local antimicrobials, oral hygiene instructions*", which was given by Assoc. Prof. Axel Spahr (Sydney) to dentists, specialists, and hygienists at the University of Technology Sydney on 6th July 2016. The lecture covered important aspects of periodontal diseases, plaque formation and the biofilm. Its main focus though was plaque control by mechanical removal and adjuvant use of antiseptic agents.

Periodontitis

Periodontitis is a common condition and the risk of developing periodontitis increases with age. According to the 2004-06 National Survey of Adult Oral Health, moderate to severe periodontitis was present in nearly 23% of Australians with its frequency increasing from approximately 7.5% in those aged 15–34 years to almost 61% in those aged ≥75 years.[1]

Periodontitis starts with infection, primarily bacterial, which stimulates a host response. The problem is that the host response involves an inflammatory reaction in addition to the immunological reaction that is mounted to eliminate the infection (**Figure 1**). Once the periodontal tissues become infected they produce pro-inflammatory cytokines and prostanoids, leading to a significant inflammation within the affected tissues. They also produce matrix metalloproteinases (i.e. collagenases), which are able to degrade collagen. In a healthy mouth, loss/damage of connective tissue and bone caused by chewing is balanced by the biological replacement of collagen and bone. In the presence of ongoing inflammation, however, the balance shifts to a net loss of collagen and bone, hence leading to a progressive degradation of periodontal tissues named periodontitis.

The influence of modifiable and non-modifiable factors on host response as well as connective tissue and bone metabolism must also be considered. Modifiable risk factors are environmental and acquired (e.g. oral hygiene, smoking, stress, diet, type 2 diabetes). Genetic risk factors that determine susceptibility to periodontal disease and regulate the host response are non-modifiable. An improperly regulated host response can produce excess inflammation in response to infection.

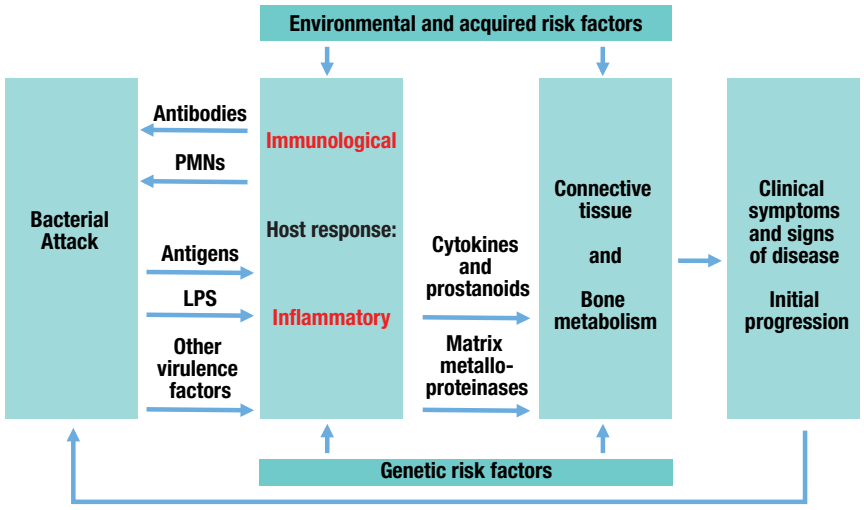

Figure 1. Pathogenesis of periodontitis. Abbreviations: LPS = lipopolysaccharides; PMN = polymorphonuclear neutrophils.

Although targeting environmental and acquired risk factors for modification should not be neglected when treating periodontitis, the primary approach is to reduce or eliminate the bacterial attack, i.e. the removal of plaque.

Plaque formation

The main aim of periodontal therapy is removal of tooth deposits, in particular plaque. Plaque is a biofilm that forms naturally on the surfaces of exposed teeth and other areas of the oral cavity (**Figure 2**). A biofilm is a complex living structure that grows according to a set of principles. It consists of a diverse population of micro-organisms that work together as a community to facilitate growth, camouflage, and protection of the biofilm. The only approach so far that has been clinically shown to be able to remove the biofilm on exposed tooth surfaces is mechanical removal.

Because every mouth is infected but not every mouth develops periodontitis, it is believed that periodontitis develops only in people whose biofilm transitions from one that is symbiotic to one that is dysbiotic. A dysbiotic biofilm is one in which there is a shift in the microflora that results in a keystone pathogen, e.g. *Porphyromonas gingivalis*, becoming dominant. The keystone pathogen induces inflammation to provide it with the factors it needs for survival, i.e. it manipulates the host response for its own benefit. It also co-opts accessory pathogens to facilitate its colonisation and to co-ordinate metabolic activities. Thus, the accessory pathogens contribute to the destructive inflammation.

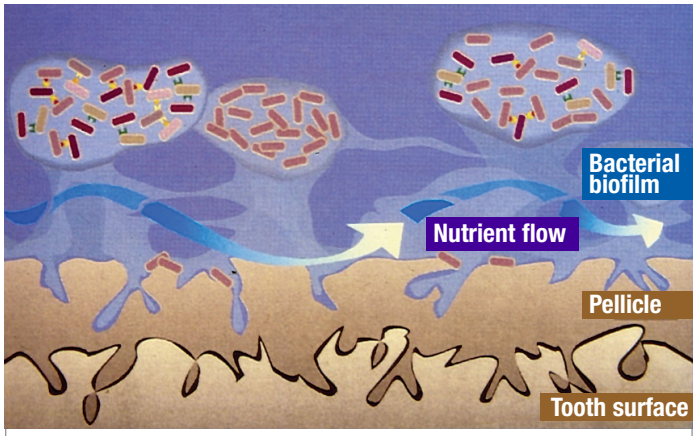

Figure 2. Dental plaque as a biofilm. Dental plaque represents a true biofilm, which consists of bacteria in a matrix composed mainly of extracellular bacterial polymers and salivary and/or gingival exudate products.

Periodontal therapy

The importance of periodontal therapy is highlighted by a landmark review of teeth longevity that showed that tooth survival after 50 years of function was 99.5% in the absence of gingival inflammation versus 64% in the presence of chronic gingival inflammation.[2] Importantly, if periodontally compromised but treated and maintained regularly tooth survival was still high (92–93%).

The main aim of periodontal therapy is plaque removal. It is not possible to remove all of the plaque; however, to prevent the initiation or further progression of periodontal disease it seems to be sufficient to reduce the quantity of plaque to below a certain threshold, the critical mass of plaque. This is the level at which there is a biological equilibrium, i.e. the quantity of remaining pathogens and intensity of host immune response are balanced, so that there is no clinical disease and further attachment loss.

The problem is that the critical mass threshold is different in different patients. Therefore, different patients will require different approaches to ongoing treatment. Once there is no longer any active clinical disease or further attachment loss the threshold will have been attained.

A landmark study by Lang et al. was conducted to determine how frequently effective oral hygiene procedures must be performed to maintain gingival health and to assess the pattern of plaque development in the mouth.[3] It revealed that plaque formation always begins interdentally and that the oral surfaces accumulate the least amount of plaque, which emphasises the importance of focusing on the interdental plaque. Importantly, the study also demonstrated that healthy gingiva around a tooth surface resulted in less plaque formation but that an inflamed gingiva promoted more plaque formation, i.e. a shift towards a dysbiotic biofilm.

PLAQUE REMOVAL — MECHANICAL

Oral hygiene instructions by dental healthcare professionals should be based on published peer-reviewed evidence of meta-analyses and systematic reviews or randomized controlled trials rather than clinical experience or collegial narrative references.

Tooth brushing

The ideal tooth brushing technique allows complete plaque removal in the least possible time without causing damage. Published evidence confirms that tooth brushing is effective in reducing dental plaque.[4]

Technique

Although the (modified) bass technique is the most commonly recommended tooth brushing technique, the most commonly used technique worldwide is horizontal scrubbing. To date, no particular tooth brushing technique has been found to be clearly superior to the others.[4] In addition, the (modified) bass technique, to be effective, requires the user to have a high level of skill, dexterity, and motivation. Patients unable to master the bass technique should be taught the correct horizontal brushing technique using a suitable brush (which has cross bristles).

Soft or hard bristles

Over the last years, soft bristle brushes have traditionally been recommended to patients by default because plaque, especially in the cervical area, is seen to be the cause of periodontitis and because of concerns that harder bristle brushes might induce gingival injury. However, the association between recession and tooth brushing is inconclusive and it requires a certain filament stiffness to remove plaque deposits. Use of a medium rather than soft bristle toothbrush should therefore be recommended with instruction that it be used with reduced pressure.

Powered or manual

Published research has consistently shown that powered tooth brushes with an oscillating-rotating action are more effective than manual brushes in removing plaque and reducing gingivitis and do not pose clinically relevant risk to hard or soft tissues.[4-7] No other type of powered tooth brush has been shown to be consistently superior to manual toothbrushes.

Oscillating-rotating powered brushes have also been shown to be significantly better than sonic power toothbrushes in plaque removal and gingivitis reduction.[8]

Interdental cleaning

As demonstrated by Lang et al., the interproximal surfaces form the most plaque.[3] Therefore, particular attention has to be paid to interdental cleaning when instructing patients.

Interdental mechanical plaque removal in addition to tooth brushing has been requested because toothbrushes do not efficiently reach into the

interdental areas. The ideal interdental hygiene tool is one that is user-friendly, penetrates easily between adjacent teeth, touches as much of the interdental surface as possible, removes plaque effectively, and does not injure hard and soft tissues.[11] It is also important that an interdental tool matches the patient's preferences; if the patient likes a particular tool, they are more likely to use it.

Dental floss

Surprisingly perhaps, the published evidence indicates that the use of dental floss as an adjunct to tooth brushing has no or only very limited effect in terms of interdental plaque removal.[9-11] Proper instruction and a high level of motivation and dexterity is necessary to make flossing worthwhile.

In a recent case report study, flossing around dental implants appeared to contribute to the development of peri-implant disease, with floss remnants being left behind due to tearing of the dental floss on rough implant surfaces.[12]

Interdental brushes

Evidence suggests that cleaning with interdental brushes is the most effective method for interdental plaque removal.[11,13] The advantage of interdental brushes is that, relative to other interdental tools, they reach more of the interdental surfaces and clean even subgingivally because they push the papilla down. An important consideration is the design of interdental brushes. Those with cone-shaped bristles seem to clean inefficiently on the "exit" (lingual) interdental surface compared with interdental brushes with straight cylinder-shaped bristles.[14]

Summary

There is no interdental tool that will work for all people; nor is there one that will not work for any individual. Therefore, oral hygiene should be customized for individual patients using clinician judgement, scientific evidence, and taking into account patient preference. The dental professional should, therefore, navigate the patient to the optimal devices tailored to their specific needs.[11] The question then becomes how can the efficacy of mechanical oral hygiene be further improved?

PLAQUE CONTROL — CHEMICAL

Mechanical plaque control is the mainstay for the treatment and prevention of periodontitis, but it requires patient cooperation and motivation. In this context, chemical plaque control agents, including antiseptic agents (mouthwash) and antibiotics (local and systemic) might be useful adjuvants for achieving the plaque critical mass threshold.

Antiseptic (antimicrobial) mouthwashes

The main indications for use of an antiseptic agent are:

1. As an adjuvant to mechanical plaque removal (brushing and interdental cleaning) in patients unable to maintain proper oral hygiene due to:
    a. physical and/or mental impairment.
    b. lack of motivation.
    c. decreased salivary rate.
2. As an alternative to mechanical oral hygiene procedures in cases in which they are contraindicated, e.g. after a surgical procedure.

Many antiseptic agents are available. However, sufficient evidence to recommend their use is available for only two agents: chlorhexidine and essential oils.

Chlorhexidine

Chlorhexidine-containing mouthwash (CHX) is generally considered to represent the gold standard for antiseptic mouthwashes by virtue of its:[15-18]

- Broad antimicrobial spectrum, including Gram positive and Gram negative bacteria, fungi, and yeast.
- High substantivity, remaining on oral surfaces for 8–12 hours, which helps to prevent bacterial recolonization.

The antimicrobial action of CHX is the result of immediate bactericidal action followed by prolonged bacteriostatic action. CHX is bactericidal at high concentration (0.12–0.2%) by cell wall disruption and is bacteriostatic at low concentration (0.02–0.06%), by altering osmotic balance in the cell.

After rinsing with CHX, 30% is retained in the mouth via attachment to oral surfaces. It is then slowly released over 8–12 hours. Therefore, the optimum CHX dosage is 20mg twice daily, i.e. 10mL of 0.2% CHX (20mg) or 15mL of 0.12% CHX (18mg). The optimum duration of rinsing is 30 seconds and duration of treatment is 2 weeks (1 bottle) for mild gingivitis and 1 month (2 bottles) for chronic or more severe disease.

CHX is not metabolised by the body, which contributes to its favourable safety profile. No carcinogenic, mutagenic, or fertility-altering effects have been reported indicating that it is safe to use in pregnancy.

The main side effect of CHX is yellow-brown staining of teeth and restorations. The staining is easily removed with an AirFlow device (sand blaster). The use of CHX formulations with an anti-discolouration system (ADS) is not recommended. CHX with an ADS has been demonstrated to have no superior effect versus placebo on oral hygiene or prevention of gingivitis.[19]

CHX prevents the new formation of plaque, rather than the further thickening of existing plaque. Professional cleaning should therefore be performed before commencing antiseptic therapy with CHX and patients should be advised to brush before rinsing with CHX. Mechanical cleaning before rinsing with CHX removes and/or disrupts the biofilm and renders tooth surfaces more amenable to CHX adhesion.

Patients should be advised to rinse with plain water after tooth brushing with dentifrice and before rinsing with CHX. Neutralisation of CHX by dentifrice additives, such as sodium lauryl sulphate and sodium monofluorophosphate, can lead to loss of antimicrobial efficacy.

Dental professionals should expect to see new calculus formation in patients after CHX treatment as CHX promotes the formation of supragingival calculus.

In summary, the findings of randomised controlled trials, meta-analyses, and systematic reviews indicate that:

- CHX is first choice for indications where optimal plaque control is the main focus, such as postoperative wound healing.

Essential oils

Essential oils-containing mouthwash (EO) has a broad antimicrobial spectrum, being active against Gram-positive and Gram-negative bacteria, as well as yeast and some viruses. The mechanism of action of EO is similar to that of CHX in that it is bactericidal at high concentrations (via cell wall disruption and cell protein precipitation) and bacteriostatic at lower concentrations (inhibition of cell growth by inactivation of essential microbial enzymes).

The substantivity of EO is up to 12 hours; therefore, the recommended use for EO is the same as for CHX, i.e. rinse for 30 seconds twice daily.

Staining and formation of calculus have been shown to be less with EO when compared with CHX.[20,21]

Essential oils are hydrophobic and require formulation with ethanol to render them more hydrophilic so that they can penetrate into the plaque where they can exert their antimicrobial action. Ethanol-free EO does not demonstrate clinical efficacy in plaque reduction.[22]

Meta-analyses and systematic reviews show that although CHX is better than EO in the control of plaque there is no significant difference between the two agents regarding reduction in gingivitis.[15,22,23] This is a surprising finding because plaque is the primary cause of gingivitis and hence CHX would be expected to reduce gingivitis more than EO. There is no difference between the two agents in their effects on gingivitis because the phenolic compounds of EO have direct anti-inflammatory and prostaglandin synthetase inhibiting activity, i.e. they reduce the inflammatory response.

There is evidence that mouthwashes can provide a benefit beyond mechanical oral hygiene alone in preventing plaque accumulation and gingivitis.[15,23,24] A meta-analysis of 29 randomized, observer-masked, placebo-controlled trials with individual-level site-specific data, compared the combined effectiveness of mechanical methods with EO (MMEO) versus mechanical methods (MM) alone.[25]

A unique feature of the meta-analysis was that the researchers performed a responder analysis, in which sites were evaluated regarding presence and absence of disease. This type of analysis allows clinicians to more easily assess the level of response to treatment. The responder analysis results showed that after 6 months of treatment, 44.8% of participants in the MMEO group versus 14.4% of those in the MM group achieved at least 50% heathy sites in their mouths and that 36.9% in the MMEO versus 5.5% in the MM group achieved at least 50% plaque-free sites in their mouths (**Figure 3**).

The researchers concluded that the addition of daily rinsing with EO to mechanical oral hygiene provided a statistically significant greater likelihood of having a cleaner and healthier mouth, which is a strong argument for use of EO.

In summary, data from randomised controlled trials, meta-analyses, and systematic reviews indicate that:

- EO appears to be a reliable alternative to CHX with respect to gingival inflammation in cases where long-term anti-inflammatory oral care may be beneficial.
- EO in addition to normal brushing may be of benefit when interdental plaque control is insufficient/difficult.

Other antiseptic agents

In terms of other antiseptic agents available, systematic reviews of the literature to evaluate the efficacy of anti-gingivitis and anti-plaque mouthwashes in long term (six months), randomised, placebo-controlled clinical trials show that:[15,16]

- Results for cetylpyridinium chloride mouthwashes were inconsistent.
- Dentifrices containing 0.3% triclosan and 2.0% Gantrez copolymer showed anti-plaque and anti-gingivitis effects.
- No evidence of efficacy for triclosan products containing either soluble pyrophosphate or zinc citrate.
- A marginally clinically significant anti-plaque effect and clinically significant anti-gingivitis effect for dentifrices with stannous fluoride.

Currently, there is no evidence of any beneficial effect with the use of so-called 'natural' mouthwashes, which commonly contain herbal ingredients, e.g. tea tree oil, aloe vera, Echinacea, etc.

Alcohol-containing mouthwashes and oral cancer

Regarding concerns that alcohol-containing mouthwashes may contribute to the development of oral cancer, comprehensive meta-analyses and systematic reviews have concluded that, based on current evidence, alcohol-containing mouthwash does not increase the risk of oral cancer, even those containing a significant percentage of alcohol.[24,26]

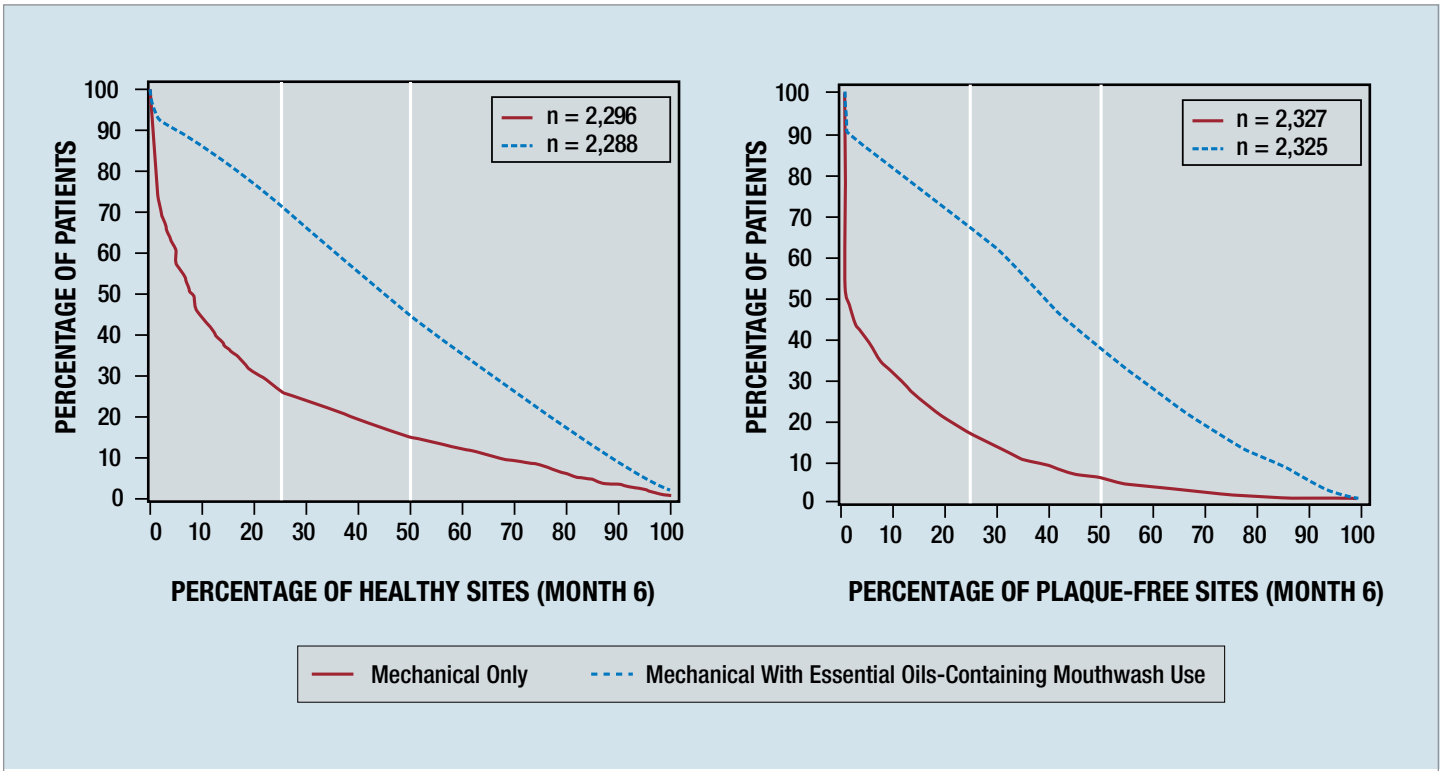

Figure 3. Responder analysis of percentage of whole-mouth healthy sites (27 studies) and plaque-free sites (28 studies) in a large meta-analysis.

By way of background, it is not the ethanol in alcoholic beverages that potentially contributes to the development of alcohol-related oropharyngeal cancer, it is the primary metabolic product of alcohol, acetaldehyde. Extra-hepatic metabolism of ethanol to acetaldehyde occurs in the oral cavity as certain plaque bacteria can produce acetaldehyde. This point helps to emphasise the importance of oral hygiene and plaque control.

Studies have shown that the acetaldehyde concentration in saliva increases after use of an alcohol-containing mouthwash but decreases rapidly to undetectable levels within 10 minutes.[24,27,28] In addition, mouthwashes with alcohol at significant concentrations (≤27–28%), even used twice daily every day, had a negligible impact on cumulative lifetime exposure of acetaldehyde compared with that derived from other sources.

Antibiotics

Reviews of the literature indicate that adjunctive local application of antibiotics after professional subgingival debridement in the treatment of periodontitis has only a temporary benefit and administration of systemic antibiotics combined with mechanical debridement can produce clinical improvements additional to those obtained with scaling or debridement alone.[29,30] Considering the limited additional benefits of adjunctive antimicrobials (balanced against possible side effects) and concerns about the development of antibiotic resistance, antibiotics should be limited as much as possible and are indicated in aggressive or severe cases only.

Summary

Antiseptic agents and antibiotics should not be used to compensate for insufficient oral hygiene or to replace accurate instrumentation (scaling/debridement). However, if the combination of mechanical hygiene and antimicrobial (and/or antibiotic) treatment reduces the quantity and quality of bacterial plaque below the critical level, i.e. where there is a biological equilibrium between remaining periodontal pathogens and host response, then a balanced system is achieved resulting in no clinical disease and no further attachment loss.

TAKE-HOME MESSAGES

- Periodontitis is a dysbiotic inflammatory disease that leads to destruction of the soft and hard tissues that support the teeth.
- The main aim of periodontal therapy is infection control to reduce the amount of plaque to below a critical level.
- Antiseptics and antibiotics do not compensate for poor oral hygiene or replace accurate instrumentation or brushing.
- CHX and EO have anti-gingivitis efficacy but act through different mechanisms: CHX via an anti-plaque effect and EO via an anti-inflammatory process.
- Current evidence supports CHX as first choice mouthwash for the acute treatment and EO mouthwash for periodontal maintenance or supportive periodontal treatment.
- The addition of EO to mechanical oral hygiene significantly increases the likelihood of having a cleaner and healthier mouth.
- Current evidence indicates that alcohol-containing mouthwash does not increase the risk of oral cancer.
- Oral hygiene practice and instruction should be evidence based and needs to customized for each individual patent.

	EO	CHX
Spectrum of anti-microbial activity	Broad (Gram +ve and Gram -ve bacteria, yeasts, and some viruses)	Broad (Gram +ve and Gram -ve bacteria, fungi, and yeast)
Mechanism of action	Bactericidal (high concentration) and bacteriostatic (low concentration)	Bactericidal (high concentration) and bacteriostatic (low concentration)
Substantivity	High	High
Plaque control	Lower	Higher
Reduction in gingival inflammation	Similar	Similar
Calculus formation (supragingival)	Less	More
Brown staining	Less	More
Indication	Maintenance phase (long-term anti-inflammatory oral care)	Acute phase (optimal plaque control)

Comparative features and relative clinical effects of essential oils-containing mouthwash (EO) and chlorhexidine-containing mouthwash (CHX) based on current evidence

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