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Prevention and therapeutic approaches to gingival inflammation

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Abstract

The most important preventive and therapeutic effort to reduce inflammation is to remove the dental plaque thoroughly. Oral self-care is thus of crucial importance to achieve and maintain oral health. There is a scarcity of scientific evidence on the most effective models for behavioural change aimed to improve oral hygiene. There is a need for randomized-controlled trials, based on behavioural sciences and performed with great methodological rigour, to investigate the usefulness of these proposed behavioural changes. Oral hygiene regimens for patients with natural teeth as well as dental implants should include brushing twice daily, inter-dental cleaning once daily and rinsing with efficient rinses as an adjunct to mechanical infection control. Power toothbrushes are preferable as they are more effective than manual toothbrushes. Inter-dental brushes seem to be most effective and useful for inter-dental cleaning. Scaling and root planing is effective in reducing inflammation and probing depths in patients with periodontitis.

Key words: behavioural change; oral hygiene regimen; periodontal treatment

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The prevalence of periodontal diseases is fairly high among adults, and approximately 5–15% develop severe disease (Oliver et al. 1998, Hugoson et al. 2008). The current preventive and treatment concepts in the management of these diseases are based on existing knowledge of the aetiology and pathogenesis of these conditions. Periodontitis is caused by pathogenic bacterial species located in the subgingival environment. These bacterial species are organized in complex communities within a biofilm, which adheres to the tooth surfaces in close vicinity to the periodontal tissues. The importance of the presence of known periodontal pathogens in well-organized bacterial communities, adherent to the root surface in the subgingival microenvironment, lies in the specific defence strategies that biofilms have evolved to overcome both the natural and the standard antibacterial defensive mechanisms. These strategies compromise the efficacy of treatment regimes, based solely on the use of chemical antibacterial compounds. These agents lack the capacity to penetrate the bacterial communities and, as a consequence, exert their antibacterial activity where it is required (Marsh 2005). Another important factor in pathogenesis is the host immune-inflammatory response, leading to chronic inflammation, responsible for both tissue destruction and any systemic inflammatory state. Anti-inflammatory medication may be, therefore, a valid adjunctive to periodontal therapy (Salvi & Lang 2005). Risk assessment has become a key element of periodontal diagnosis, given that individual susceptibility will eventually modulate how the host is able to control the bacterial challenge. Of the known risk factors, there are some, such as the genome, that cannot be modified and, as a consequence, are not influenced by a preventive or a therapeutic intervention. The control of others, however, has become a key component in modern periodontal therapy, including strategies aimed at smoking cessation, weight loss and achieving a well-controlled systemic condition (Bergström 2006).

In spite of the new knowledge on the aetiology and pathogenesis of these diseases, their prevention is still based on the combination of compliance with self-performed plaque control and by professional plaque and calculus removal at regular dental visits. Oral self-care is of crucial importance to achieve and maintain oral health and

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this is achieved mainly by the use of either a manual or a powered toothbrush, together with flossing or other methods of effective inter-dental cleaning (Löe et al. 1965, Axelsson et al. 2004). There is substantial evidence that shows that through toothbrushing supported by other mechanical or chemical cleansing procedures, plaque and gingivitis/periodontitis can be controlled most reliably (Lindhe & Nyman 1984, Axelsson et al. 2004, Schiffer et al. 2007). Since removal of plaque is proven to prevent gingival inflammation and as gingivitis precedes periodontitis, it is reasonable to assume that a thorough oral hygiene will prevent the transition from gingivitis to periodontitis (Lindhe & Rylander 1975, Lang et al. 2005). Some authors, however, have questioned this statement, arguing that there are no randomized-controlled trials indicating that improved oral hygiene prevents or controls chronic periodontitis (Hujoel et al. 2005). At present, both primary prevention of gingivitis and primary and secondary prevention of periodontitis are based on the achievement of sufficient plaque removal. Almost 50 years of experimental research, clinical trials in different geographical and social settings have confirmed that effective removal of dental plaque is essential to dental and periodontal health (Löe 2000).

Behavioural Aspects

Personal oral hygiene refers to the effort of the patient to remove supragingival plaque. Despite the simplicity of plaque control measures, the majority of the population is not able to comply effectively and, as a result, develop gingivitis. Improvement in a patient's oral hygiene is often accomplished through the cooperative interaction between the patient and the dental professional. Preventive programmes thus aim to improve the patient's oral hygiene by education. Patients are supposed to visit the dental office regularly for professional plaque control and to assure an optimal oral self-care (Axelsson et al. 2004). This approach may create a passive patient because the responsibility in self-care is deferred to the dental professional (Hamman Calley et al. 2000). This preventive approach has, however, often been successful for some patients (Axelsson et al. 2004), but still there are many individuals who fail to comply. An actual patient-centred approach needs to be focused more on the behavioural aspects than on the biomedical strategies. Without *compliance*, which has been described as the degree to which a patient follows a regimen prescribed by a dental professional, a good treatment outcome will not be achieved. Today, the term adherence is more widely used than compliance (Lutfey & Wishner 1999, Silverman & Wilder 2006). *Adherence* implies a more active patient. Many patients are well informed and know what is necessary to be done, but still they do not comply. Compliance and adherence in general depend on several general factors, such as the patient's personality and other social and demographic factors. There are, however, other specific factors, such as the severity of the disease, the time necessary to fulfil the recommendations, their complexity and effectiveness and the relationship between the caregiver and the patient, which have an important impact on the end result (Blinkhorn 1993, Camner et al. 1994, Rydén & Stenström 1994). Patients with severe periodontitis often experience their disease as a serious problem (Abrahamsson et al. 2008) and consequently, these patients would be more eager to comply with oral hygiene recommendations better than healthy or gingivitis patients (Barker 1994). Effective oral hygiene practices require time and energy and it may be too overwhelming for many subjects, mostly when they are committed to use too many and too complicated oral hygiene aids (Johansson et al. 1984). In addition, the patient's own oral hygiene efforts are a life-long commitment, with results that may not be obvious in the short run. The relationship between patients and caregivers is also of great importance. It has been shown that patients comply with recommendations from dental hygienists to a greater extent than recommendations from dentists (Berndsen et al. 1993), also being less negative towards dental hygienists than towards dentists (Öhrn et al. 2008).

The efficacy of the different interventions to increase patient's adherence to oral hygiene is largely unknown. The role of patient education usually results in increased knowledge of periodontal disease but this increased knowledge does not necessarily result in a behavioural change (Stewart et al. 1996). A Swedish systematic review on Chronic Periodontitis by the Swedish Council on Technology Assessment in Health Care (SBU 2004) reported the efficacy of education on oral health prevention. The authors concluded that repeated information and instruction by dental professionals improved knowledge, but any conclusions about the efficacy of such initiatives for reduction of gingivitis could not be drawn. Watt and Coworkers also found in a systematic review that educational interventions in the majority of the studies reduced plaque and gingival bleeding in the short term but that the clinical significance of these changes was questionable and they suggested longer follow-up studies (Watt & Marinho 2005).

The efficacy of psychological interventions to improve adherence to oral hygiene instructions in adults with periodontal disease was recently studied in a systematic review (Renz et al. 2007). The authors reported that psychological approaches can improve oral hygiene-related behaviours; however, the authors questioned the methodological rigour in the design of most of the trials evaluated. There is a need for research in this area including the assessment of the complexity that characterizes socio-biological pathways (Kay & Locker 1996, SBU 2004, Newton 2005, Newton & Bower 2005).

There is a growing interest in applying oral health behavioural models used in medicine, but very few have been tested. Studies based on the *theory of planned behaviour* have shown that the intention to brush the teeth was related to the reported frequency of toothbrushing and that attitudes, subjective norms and perceived behavioural control were related to intention. However, even with the intentions of performing oral hygiene, some individuals fail to fulfil their intentions (Ajzen 1991). These results indicate that it is possible to predict oral hygiene habits to some extent, in the same manner that confidence in self-efficacy may be a predictor for self-care in diabetes (Tedesco et al. 1991, Syrjälä et al. 1999, 2002).

Some studies have recently integrated cognitive behavioural techniques, such as action plans, into daily oral hygiene regimens (Philippot et al. 2005, Jönsson et al. 2006, Schütz et al. 2006, Sniehotta et al. 2007). In all these studies, the interproximal cleaning frequency increased, indicating that target planning was effective to improve oral hygiene.

The *trans-theoretical model* based on stages of change has also been suggested as an appropriate model to

improve oral health compliance and adherence (Prochaska et al. 1992, Tillich et al. 2003, Schütz et al. 2008). It has been shown that patients act differently depending on their stage of change (Schütz et al. 2007); however, there is limited evidence on the efficacy of oral hygiene interventions based on stages of change. Motivational interviewing (MI) has been proposed as an effective method for oral hygiene education (Miller & Rollnick 2002) and it has been used in the prevention of dental caries with promising results, which warrants further attention in other oral health contexts (Weinstein et al. 2006). Stewart et al. (1996) carried out a psychological intervention including a model similar to MI based on stages of change and demonstrated a significant increase in flossing self-efficacy. They did not report, however, how the stage of change model was used.

In summary, in order to broaden the perspective beyond the biomedical field, there is a need to study the different educational and behavioural models applied to oral self-care. In addition, although it would be ideal to deliver individually tailored preventive regimens, there is a scarcity of scientific evidence on the factors that influence patients' adherence to oral hygiene and on the predictors for certain oral health behaviours.

Oral Self-Care

Mechanical plaque control

Oral hygiene prevention is based on compliance with self-performed plaque control, mainly through the use of either a manual or a powered toothbrush, together with effective inter-dental cleaning (Nicholas 2008). The usual recommendation of toothbrushing twice daily and inter-proximal cleaning once daily irrespective whether there are natural teeth or dental implants still holds today (Brothwell et al. 1998, Attin & Hornecker 2005, Claydon 2008). Despite the fact that most individuals claim to brush their teeth at least twice a day, few, however, clean inter-proximally on a regular basis and it is clear from both epidemiological and clinical studies that mechanical oral hygiene procedures, as performed by most subjects today, are insufficient to control supragingival plaque formation and to prevent gingivitis and the more severe forms of periodontal disease (Bader 1998, Wilson 1998, Hugoson et al. 2005). The addition of dentifrices may be a vehicle to provide effective caries prevention with different fluoride-containing formulations, as well as antimicrobial and/or anti-inflammatory substances aimed at the control of gingivitis. In spite of this, the quality of self-performed mechanical plaque removal is usually not sufficiently effective and there is a need to complement it with professional interventions to effectively treat and prevent gingivitis (Weijden & Hioe 2005).

The need for appropriate time and manual dexterity, together with the complexity of oral hygiene aids, limits the efficacy of mechanical plaque control, mostly inter-proximal cleaning. The most common inter-dental cleaning aids are dental floss, toothpicks and inter-dental brushes. Its choice needs to be tailored to the size and shape of each inter-dental space and the patients' acceptance for the method (Claydon 2008). In fact, inter-dental brushes are usually considered simpler and less time consuming than dental floss (Christou et al. 1998, Ishak & Watts 2007). Studies on the efficacy of flossing are inconclusive due to short follow-up evaluation times and mostly performed on adolescence or young adults (Finkelstein et al. 1990, Sicilia et al. 2003, Halla-Júnior & Oppermann 2004, Sniehotta et al. 2007). The oral health professionals should determine, in collaboration with the patient, whether high-quality flossing is an achievable goal because a certain manual dexterity is necessary to perform proper flossing (Berchier et al. 2008).

Triangular toothpicks are easy and convenient to use, and according to a recent systematic review, their regular use reduces inter-dental gingival inflammation by reducing the bleeding tendency, even if they do not have any significant effect on visible inter-dental plaque or gingival index (Hoenderdos et al. 2008). Inter-dental brushes are frequently recommended for wider inter-proximal spaces. A recent systematic review reported that inter-dental brushes are able to remove more dental plaque than dental floss or wood-sticks, although the evidence on the differential effect on gingival inflammation is inconclusive (Slot et al. 2008).

In terms of toothbrushing, several systematic reviews have concluded that power toothbrushes are significantly more efficient than manual toothbrushes to remove plaque and to prevent gingivitis (Sicilia et al. 2002, Heanue et al. 2003, SBU 2004).

Chemical plaque control

The use of a toothbrush is usually combined with a dentifrice with the purpose of facilitating plaque removal and applying agents to the oral surfaces for therapeutic or preventive reasons. Dentifrices containing stannous fluoride, amine fluoride/stannous fluoride or chlorhexidine (CHX) have been shown to be more effective in controlling gingivitis than conventional dentifrices with fluoride (Archila et al. 2004, Lang et al. 2004, Madléna et al. 2004, SBU 2004). It was also concluded in two systematic reviews that dentifrices containing triclosan/copolymer were also more effective than conventional dentifrices (SBU 2004, Gunsolley 2006). This significant superior effect of triclosan has not been demonstrated in all populations (Lang et al. 2002, Bogren et al. 2008) and, moreover, triclosan-containing products have raised concern due to possible environmental hazards.

Mouthrinses are also extensively used as an adjunct to mechanical cleaning, because they are easier and more convenient to use than mechanical cleaning aids. CHX has been widely used in dentistry for many decades, and its effect as an effective antiplaque and antigingivitis agent has been scientifically proven in numerous studies and confirmed by two systematic reviews (SBU 2004, Gunsolley 2006). CHX, however, has several drawbacks that significantly limit patient compliance because it causes tooth discoloration, buildup of supragingival calculus and taste alterations (Ciancio 2000). Mouthrinses containing essential oils have also demonstrated their efficacy as an adjunct to mechanical cleaning in the reduction of plaque and gingivitis (Santos 2003, SBU 2004, Gunsolley 2006, Stoeken et al. 2007, Sharma et al. 2008). Mouthrinses containing cetylpyridinium chloride have a lesser antiplaque and antigingivitis efficacy, although they have been shown, in a recent systematic review, to confer a small but significant additional benefit in reducing plaque and gingival inflammation in healthy subjects with good to moderate gingival health (Haps & Slot 2008).

Professional Interventions

Mechanical instrumentation

Besides oral hygiene education, dental professionals may provide preventive

and therapeutic measures in the management of periodontal diseases, such as dental plaque and calculus removal, together with the elimination of retentive factors for dental plaque. There is limited value in providing professional mechanical plaque removal without oral hygiene instruction, but it might be beneficial for patient satisfaction (Needleman et al. 2005).

In the treatment of destructive periodontal diseases (periodontitis), cause-related therapy provided by dental professionals involves mechanical disruption of plaque and calculus deposits, using various instruments and techniques, sometimes coupled with the administration of adjunctive antimicrobial drug therapy. The effects of this therapeutic approach are assessed by the comparison of probing attachment levels and probing pocket depths (PPD) before and after treatment. A number of systematic reviews on the efficacy of mechanical non-surgical periodontal therapy have been published during the last decade. There is a consensus among these reviews that subgingival debridement, combined with proper supragingival plaque control, is an effective treatment modality in reducing PPD and improving clinical attachment levels (CAL). The effectiveness of these procedures decreases with increasing probing depth (PD), especially when PDs exceed 5 mm (Hallmon & Rees 2003, SBU 2004, Suvan 2005).

The traditional approach to root debridement, scaling and root planing (SRP), involves the use of hand instruments, available in various designs, described as curettes, hoes or scalers. The process is time consuming and physically demanding, with deposits on root surfaces ranging typically from simple biofilms to hard tenacious calculus that requires attention to detail, manual dexterity and a thorough knowledge of tooth anatomy to eliminate. Power-driven instruments differ from hand instrumentation in that they are relatively blunt and rely on the action of a vibrating tip, driven by sonic or ultrasonic technologies, to disrupt the plaque and calculus. The disadvantage is that the clinician has little, if any, tactile control and the powered instrument may have the potential to damage the root surface, producing indentations and unwanted scratches in the hard tissue surface. Despite the implications of such damage to the outcome of therapy not having been demonstrated, root surface damage is undesirable. Systematic reviews assessing the efficacy of power instrumentation in the treatment of periodontitis have found that clinical outcomes are similar in terms of pocket reduction and attachment gain, when compared with hand instrumentation; however, machine-driven instruments may be faster and easier to use (Tunkel et al. 2002, Suvan 2005). Non-surgical cause-related therapy has shown limitations in the treatment of deep pockets and sites that are difficult to reach, such as furcations and intra-bony defects. In these situations, the treatment goal is to reduce PPD, maintain or improve CAL and reduce the incidence of bleeding on probing. Resolution, in some cases, may be attained only if SRP is provided in combination with flap surgery that facilitates access to root debridement. Indeed, a number of systematic reviews on the efficacy of mechanical non-surgical periodontal therapy, when compared with access flap surgery, have shown improved periodontal outcomes with surgery in pockets deeper than 4 mm (Heitz-Mayfield et al. 2002, SBU 2004).

Pharmacological application

Because periodontitis is a chronic infection, the use of systemic antimicrobials, as part of its therapy, has been debated for decades. Given the limited capacity of currently used antimicrobials to penetrate subgingival biofilms, it is suggested that the use of antimicrobials in the treatment of periodontitis should be as an adjunct to mechanical debridement, not an alternative therapy. The possible adjunctive benefit of using systemic antimicrobials in the treatment of periodontitis has been reported in two systematic reviews (Haffajee et al. 2003, Herrera et al. 2008), which concluded that the overall additive effect of antibiotics on clinical parameters was limited. Only in specific clinical situations, including patients with very deep pockets, progressive or ''active'' disease, or with specific microbiological profiles, did adjunctive antimicrobial therapy result in a significant improvement in the clinical outcomes. An alternative approach to the systemic administration of antimicrobials is to apply the drug directly into the diseased pocket. In this way, locally delivered antimicrobials may provide an effective concentration of the drug at the site of infection, with minimal systemic load and a low risk of bacterial resistance. A recent systematic review of clinical outcomes with the adjunctive use of locally delivered antimicrobials compared with SRP alone has demonstrated that a clinical benefit, albeit to a modest degree, can be achieved from such adjunctive therapy (Suvan et al. 2008). Previous systematic reviews had questioned the clinical significance of the statistically significant benefits (Hallmon & Rees 2003, Hanes & Purvis 2003). The concerns were based largely on cost/benefit considerations, suggesting that the use of locally delivered antimicrobials should be restricted to sites that do not respond adequately to mechanical instrumentation.

Although the primary aetiologic basis of periodontal disease is the accumulation of bacteria at the biofilm–gingival interface, the excessive host inflammatory response and/or inadequate resolution of inflammation is critical to the pathogenesis of the tissue destruction that occurs in periodontitis. Because the major drivers of tissue destruction are matrix metalloproteinases (MMPs), cathepsins and other osteoclast-related mediators, agents that directly or indirectly block the activity of osteoclasts may represent potential ''bone-sparing'' therapies to be used as an adjunct to traditional periodontal therapy. Research that demonstrated the protective effects of common non-steroidal anti-inflammatory drugs (NSAIDs) and tetracyclines led to the concept of host modulation as a means of limiting the progression of periodontitis. The first attempts at using NSAIDs as an adjunct to standard periodontal therapy were not very successful, enhanced clinical outcomes being countered by secondary effects linked to long-term anti-inflammatory medication. The discovery of the potential inhibitory effects of the MMP-8 and MMP-13 protease mechanisms associated with low-dose tetracyclines and tetracycline analogues has renewed interest in previously discredited treatment regimes (Salvi & Lang 2005). Indeed, recent systematic reviews have shown that subantimicrobial-dose doxycycline therapy is an effective adjunctive systemic therapy to the traditional mechanical therapies (SRP) in the management of periodontitis. Improved outcomes persist for $\geqslant$9 months in adults with chronic periodontitis, as observed in gains in CAL and reductions in PD (Giannobile 2008).

Although questions remain regarding optimizing treatment efficacy, while limiting any potential adverse effects, the evidence clearly suggests a strong

potential for the modulation of the host response in aiding disease management, including traditional mechanical therapy (Preshaw 2008).

As the understanding of the pathways of inflammation has matured, a better understanding has emerged in respect of the molecular basis of the resolution of inflammation. Resolution of inflammation is an active, agonist-mediated, well-orchestrated return of tissue homoeostasis. A growing body of research suggests that chronic-inflammatory periodontal disease involves a failure of resolution pathways to restore homoeostasis. The isolation and characterization of resolving agonist molecules has opened a new area of research to investigate endogenous lipid mediators of resolution as potential therapeutic agents for the management of inflammatory periodontitis. Work in animal models of periodontitis has revealed the potential of this therapeutic approach, based on the use of pro-resolvin lipid mediators that contribute to the restoration of tissue homoeostasis (Van Dyke 2008). Such pro-resolving molecules include lipoxins that are endogenously produced from the metabolism of arachidonic acid and other exogenous pro-resolving molecules, including resolvins and protectins derived from omega-3 polyunsaturated fatty acids. These newly identified lipid mediators represent a potentially powerful intervention that stimulates resolution pathways, leading to the restoration of homoeostasis, possibly without the multiple side effects ascribed to traditional anti-inflammatory antagonist-based treatments. Clinical studies in humans will be required to elucidate the actual efficacy of this therapeutic approach.

Smoking cessation

Smoking cessation counselling (TUC) is an important professional intervention in the management of periodontal diseases because patients who continue to smoke will respond poorly to periodontal therapy and will be more amenable to relapse (SBU 2004, Labriola et al. 2005) and, consequently, TUC should be included in any routine oral health care programme (Needleman et al. 2006). TUC requires even more behavioural change than oral hygiene, and thus a referral to the adequate professional may be necessary in many situations. Behavioural interventions for tobacco use conducted by dental staff, however, have been shown to increase tobacco abstinence rates (Carr & Ebbert 2007). Both MI and stage of change have been suggested as models in smoking cessation, although they need to be tested in dental settings.

Concluding Remarks

Although there is a clear need to implement different models for behavioural change, their usefulness must be proven by a well-designed clinical investigation. These models need to be based on behavioural sciences and be performed with great methodological rigour. Recommendations for patients with natural teeth as well as dental implants should include brushing twice daily, inter-dental cleaning once daily and rinsing with effective mouthrinses as an adjunct to mechanical plaque control. The choice of the oral hygiene regimen needs to be tailored to the patient. Mechanical infection control (SRP) is an effective treatment in the control of periodontal infections and it is a fundamental part of any supportive periodontal programme.

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