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Review Article

Air-Polishing in Subgingival Root Debridement during Supportive Periodontal Care: A Review

Janaphan K, Hill RG, Gillam D*

Oral Bioengineering, Institute of Dentistry, Barts and the London School of Medicine and Dentistry, Queen Mary University, London, UK

***Corresponding author:** David Gillam, Oral Bioengineering, Institute of Dentistry Barts and The London School of Medicine and Dentistry, Queen Mary University, UK

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Abstract

Several investigators have reported on the benefits of using of air polishing procedures for subgingival debridement as an alternative treatment approach for periodontitis patients during supportive periodontal care in terms of a shorter duration of treatment as well as an improvement in patient outcomes. This review provides an overview of the polishing powders used in air polishing procedures as well as the effectiveness of air polishing procedures in subgingival debridement of periodontal pockets during supportive periodontal care.

Introduction

Periodontitis has recently been defined as “a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms and characterized by progressive destruction of tooth-supporting apparatus” [1]. The current concept of treatment is, however still mainly based on the principle of biofilm control [2]. The presence or accumulation of a microbial biofilm, without any disruption, will lead to loss of symbiosis between the host’s immune-inflammatory responses. Consequently, this may progress to gingivitis [3] and in susceptible individuals, progress to periodontitis [4]. Dental biofilm/plaque removal is therefore fundamentally important to prevent periodontal disease [5]. Periodontitis patients remain at high risk for disease recurrence or progression even following the completion of active periodontal therapy, particularly where patient compliance is poor. These patients require specifically designed Supportive Periodontal Care (SPC) consisting of various preventive and therapeutic interventions scheduled at interval three to a maximum of 12 months to control periodontal re-infection [6,7]. Supportive periodontal care aims to maintain periodontal stability among periodontitis patients following a successful active periodontal therapy. The reinforcement of oral hygiene instruction, patient motivations, and control of any risk factors, Professional Mechanical Plaque Removal (PMPR), and subgingival instrumentation at residual pockets are included in this stage of treatment. According to Sanz et al., [7] it is recommended that ‘’routine PMPR should be performed as part of a supportive periodontal care program. The true impact of the impact of Professional Mechanical Plaque Removal (PMPR) intervention in patients enrolled in a maintenance program, however, is still inconclusive. This is mainly because PMPR during SPT is usually delivered together with different procedures. Nevertheless, the evidence supports that PMPR may limit the incidence of tooth loss and clinical attachment level changes [8]. Conventional techniques in PMPR intervention utilize hand curettes and/or ultrasonic scalers. However, repeated instrumentation with these techniques over time invariably causes some degree of root structure loss [9-12]. According to Mombelli [13], the subgingival biofilm may not mineralize to form dental calculus during the maintenance visits and therefore aggressive treatment modality such as air-polishing is preferable to avoid tooth surface loss and its consequences. The introduction of air polishing procedures for subgingival debridement during supportive periodontal care has demonstrated promising results as an alternative treatment approach for periodontitis patients under supportive periodontal care [14]. Air-polishing is also used for other various purposes in dentistry such as caries or restoration removal, cavity preparation, removal of orthodontic adhesive [15-17].

Aim

The aim of this current review is to provide a comprehensive overview on air-polishing as a treatment modality during supportive periodontal care (SPC) and to evaluate the powders used in air polishing procedures.

Materials and Methods

The literature review was conducted by Kitichai Janaphan (KJ) during 2019/20 and included available papers up to July

2020. The following databases were used in the review: PubMed, Embase, Scopus, The Cochrane Library, and the Web of Science together with hand-searching of Journals such as the Journal of Clinical Periodontology, Journal of Periodontology, Journal of Periodontal Research, and Journal of Dental Research. The keywords or combination of words used in the research were: 1) air-polishing, air-polishing devices, air abrasion, air-flow, air powder abrasive, air polish, 2) subgingival debridement, subgingival instrumentation, biofilm/plaque removal, mechanical tooth cleaning, professional mechanical plaque removal and 3) supportive periodontal treatment, supportive periodontal care, maintenance care, maintenance therapy.

Selection Criteria

Inclusion criteria

i) Only studies written in English were selected

ii) In vitro, animal, and human studies

Exclusion criteria

Studies not in the English language

Studies using air-polishing procedures for dental implants

Efficacy of air-polishing in Supportive Periodontal Care (SPC)

The clinical efficacy of air-polishing during Supportive Periodontal Care

The application of air-polishing is one of the available techniques for subgingival debridement aiming to disrupt and/or remove the biofilm. It is performed together with supragingival biofilm and dental calculus removal [18]. Dental calculus is a secondary aetiological factor in the development and progression of periodontitis. It is generally covered with an unmineralized bacterial layer. This physical barrier prevents optimal self-performed oral hygiene which could lead to unsuccessful non-surgical periodontal therapy [19]. Thus, removing both the bacterial biofilm and dental calculus is still the cornerstone for successful periodontal treatment [20]. It should be noted that air-polishing cannot remove dental calculus, and therefore hand or ultrasonic scalers are utilized for this purpose. The presence of calculus does not seem to impair the efficacy of air-polishing subgingival debridement [21]. However, the supplementary use of the air-polishing device of periodontal pockets together with scaling and root planning did not show a superior clinical effect [22,23].

The efficacy of subgingival air-polishing during supportive periodontal therapy has been investigated in several clinical trials [24-27]. The repeated subgingival application in residual pockets (PD > 4mm) during periodontal maintenance could reduce the number of pockets similar to ultrasonic debridement [24]. In summary, air polishing is capable of effectively remove the subgingival biofilm and it offers similar treatment outcomes (Probing Pocket Depth [PPD] Bleeding on Probing [BOP], and Clinical Attachment level [CAL]) when compared to conventional therapy [28]. Furthermore, a systematic review comparing ultrasonic debridement with subgingival air polishing in supportive periodontal therapy showed that neither ultrasonic debridement nor air-polishing demonstrated superior clinical effects [29]. Both treatment modalities showed similar clinical efficacy in both single- and multi-rooted teeth without furcation involvement [28]. Nevertheless, air-polishing resulted in less patient discomfort and a higher level of patient acceptance which is in accordance with the previously reported systematic review [30].

A new nozzle design for subgingival debridement further extends the application of air-polishing. This design feature reduces the pressure of the jet spray by approximately 1 bar and allows both the air and powders to exit horizontally, thus minimizing the risk of subcutaneous emphysema [24]. For subgingival applications using this new nozzle, the periodontal pocket up to 9 mm was tested and no adverse events were detected [24-27].

The use of powders in air polishing procedures

The mechanism of air polishing devices is to generate a slurry pressurized air, water, and abrasive powder [31]. The polishing powder is an integral part of the efficacy, air polishing without powder failed to effectively remove the dental biofilm [32]. Air-polishing is different from air abrasion in which the later means the cutting or abrading of dental tissue with a powder composition with the aid of a power jet device. Ideally, powders used in air-polishing in periodontal procedures should not abrade the dental tissues while effectively removing the dental biofilm. A powder composition for air polishing generally comprises water-soluble organic particles as the main cleaning agent, anti-caking agents used to facilitate the flow of the powder, and anti-hypersensitive particles such as silica which are able to block or occlude the open dentinal tubules on the exposed root surface. Examples of water-soluble particles are glycine and erythritol. According to Petersilka [14], if the powders are not water-soluble, this may complicate their subgingival application due to the difficulty of removing the remnant powders from the gingival sulcus after the treatment.

Traditionally, sodium bicarbonate ($NaHCO_3$) with a particle size up to 250 microns was used for the air-polishing application. The high abrasiveness of this powder, however, limits its application to removing heavily stained teeth supra-gingivally [28]. Despite the effectiveness of plaque and stain removal, a prolonged application of a sodium bicarbonate powder can potentially abrade the enamel surface and increase the surface roughness of the restoration [33,34]. Furthermore, $NaHCO_3$ powders are contraindicated for a sodium-restricted diet and patients with renal disease [35]. Glycine, a highly water-soluble amino acid with a particle size range from about 25-65 microns, has been introduced for the use of air-polishing. It has a lower Mohs hardness index than $NaHCO_3$ powders and is considered safe to use on root surfaces and gingiva [36,37]. An in vitro study reported that a glycine powder successfully removed the biofilm more effectively on both dentine and cementum while being about five times less abrasive than $NaHCO_3$ powders [32]. A consensus conference for using air-polishing devices with glycine powders reported that this treatment modality was considered both safe and effective for biofilm removal from tooth surfaces and restorative materials. Furthermore, its effectiveness was indicated for both supra- and subgingival application [38].

Erythritol is non-toxic sugar alcohol containing 0.3% chlorhexidine and is a finer powder than glycine with an average particle size of about 14 microns. This power is normally used as an artificial sweetener [39] as it can effectively be absorbed and excreted from a human body since it cannot be metabolized [40]. The powder is designed specifically for subgingival application. There is some evidence indicating that erythritol has an antimicrobial effect against *P.gingivalis* [22,40], which is a keystone pathogen in periodontitis [41]. The addition of chlorhexidine into erythritol powder is mainly for conservative purposes and it is still unclear about the therapeutic effect of including chlorhexidine [26]. Trehalose, which is a nonreducing and noncariogenic disaccharide [42], has recently been introduced for air-polishing applications. The power diameters of 25-35 microns are similar to the diameter size of glycine powder which is applied sub gingivally in residual periodontal pockets of patients under maintenance therapy. The results showed that the clinical outcomes were comparable to ultrasonic debridement with less patient discomfort [43].

Bioactive glass powders have also been developed for air-polishing treatment. They possess the ability to chemically react with tooth surfaces once exposed to an aqueous environment in the oral cavity. This mechanism results in the occlusion of the dentinal tubule and alleviation of Dentinal Hypersensitivity (DH). A study reported a 44% reduction in sensitivity to cold air stimulation after air-polishing application with a bioactive glass (45S5), whereas sodium bicarbonate resulted in a 17% increase in sensitivity. The results demonstrated that using bioactive glass for dental prophylaxis was more effective for desensitizing and whitening effect while provided better patient comfort during treatment [44].

The anti-microbial effects of air-polishing

According to Magnusson, et al. [45] the recolonization of a subgingival microbiota, spirochetes, and motile bacteria, is re-established approximately three months after treatment if no preventive measures are implemented. The management of these subgingival dysbiotic microorganisms is challenging since periodontitis patients are those with an aberrant immune response [46]. To assess the microbiological effects of air-polishing, various methods of subgingival biofilm samples collection and analysing techniques have been employed [24,25,27,47]. Most studies used a sterile paper point and curette to collect the samples and bacterial detection and quantification methods include culture method, real-time Polymerase Chain Reaction (PCR), checkboard DNA-DNA hybridization, and 16S rDNA sequencing.

Repeated subgingival air-polishing with erythritol powders in non-resolving sites during periodontal maintenance resulted in the reduction of the number of deep pockets similar to ultrasonic debridement procedures leading to a lower detection of *Aggregatibacter actinomycetemcomitans* [26]. Flemmig, et al. also showed that the full-mouth application of air-polishing including supra- and subgingival on all teeth (including the oral mucous membranes) could result in a beneficial shift of the oral microbiota when compared to conventional debridement [48]. In contrast, it was reported that on a microbiological level, air-polishing did not demonstrate any superior outcomes in the reduction of periodontal pathogens when compared to hand or ultrasonic instrumentation [24,27,49]. Recently, the effect of air-polishing on a potentially beneficial shift of the subgingival community among patients during a three-month maintenance interval was investigated by Lu et al. [50]. The patients in this split-mouth controlled trial received regular periodontal maintenance and showed relatively stable periodontal conditions. Using 16S rDNA sequencing, subgingival plaque samples were analyzed. Both air-polishing and ultrasonic scaling resulted in the reduction of microbial richness, diversity, and pathogenic microbiota while increased the proportion of beneficial bacteria. In summary, air-polishing could promote a stable periodontal condition during the three-month interval by reducing the pathogenicity of the subgingival microbiome and counteracting the rebound of periodontal pathogens due to the recolonization of the microflora.

The effect of air-polishing on patient-related outcomes

Patient perception of the experience of pain and discomfort during periodontal treatment is crucial as it may affect the long-term compliance of patients. Patient outcomes are usually assessed by either a visual analogue scale or a patient interview and may be useful in evaluating patient perception. Air-polishing devices do not produce an unpleasant scraping or vibratory sensation and, as such could potentially offer an improved patient perception of the procedure with less discomfort. A secondary beneficial outcome could result in the reduction of DH as a smear layer covering the dentinal tubules is produced [51]. Several investigators compared hand or ultrasonic debridement with air-polishing and assessed the perception of pain and root hypersensitivity using a Visual Analogue Scale (VAS), the results from these studies indicated that air-polishing significantly induced less pain [24,26,43,47]. A systematic review also demonstrated that air-polishing with glycine or erythritol powders resulted in less discomfort during treatment compared with hand or ultrasonic instruments [30]. In summary, subgingival air-polishing, specifically with glycine or erythritol powders, is more acceptable by patients since this causes less gingival irritation and a lower perception of pain during treatment. Air-polishing is therefore a more attractive treatment modality to patients since it requires less chair-time compared to conventional methods [49]. The time required for supragingival stain removal with air-polishing was 3.15 times faster than with conventional methods [52]. The application time of 5s or up to 20s per tooth surface is recommended for each treatment session. Theoretically, if 5s is used to remove biofilm, it would take about 9 minutes to treat 28 teeth [21]. Practically, the average time for treating periodontal pocket >5 mm was 0.5 minutes/site for air-polishing compared to 1.4 minutes/sites with Gracey curettes [24].

Safety of air-polishing devices

Tooth surface loss from air-polishing will depend predominantly on the application time [53], the spray distance [54], the settings of powder and water, and the abrasiveness of the powders including their sizes, hardness, and shapes [37]. Surprisingly, no significant difference in root damage was observed between the different angulation of the nozzle [37,53]. Although abrasive powders have similar hardness value as dentine, air pressure can accelerate the particles producing enough kinetic energy to cause surface abrasion [51]. An increase in the power setting will significantly increase a powder emission rate and subsequently the degree of tooth substance loss. The spray distance of 2-5 mm will not produce significant differences, whereas the distance of 6mm will result in significantly less dentine defects [54]. Also, the depletion of the powder present in the powder chamber will decrease the powder emission. Thus, operators should refill the powder chamber to the recommended level before using the devices to ensure their effectiveness [55].

Air-polishing on denuded dentine or cementum with $NaHCO_3$ powders should however be avoided [14,56], whereas glycine powders can be safely applied to human root surfaces and gingiva [56]. From the experiment, it was shown that around 150 microns of root substance loss is expected if a $NaHCO_3$ powder is used [52,53]. This is considered not to be safe since the thickness of cementum around the tooth neck is about 20-50 microns thick [57]. By way of contrast, using a less abrasive powder such as glycine could result in an approximately 80% reduction of loss of the root structure whilst remaining effective in removing the dental plaque biofilm [32]. The use of $NaHCO_3$ air-polishing could also result in severe epithelial erosion [58]. The lower abrasive powders such as glycine, with smaller sized particles which are about 4X smaller than $NaHCO_3$ powders, caused only minor erosions of gingival epithelium and were observed to be less aggressive than hand instrumentation if applied appropriately [59]. Nevertheless, 14 days after debridement, complete epithelial healing was observed in all types of powders used.

One potential problem is subcutaneous emphysema which is a potentially life-threatening complication that has been observed after using air-polishing devices [60]. The air can penetrate subcutaneous or submucosal tissue and may spread into deeper spaces along the fascial planes, the thorax, and mediastinum, causing serious complications [61]. The mixture of trapped non-sterile air, powder, and water in the subcutaneous space can potentially cause serious infection. Overall, the incidence of subcutaneous emphysema is very rare [62]. The available data in relation to subcutaneous emphysema is, however, based on case reports. In most cases this complication is resolved in several days without any serious complications [61,63,64]. It should be noted that these results were from a controlled research environment performed by experienced practitioners [65] and as such information regarding the keratinized tissue around natural teeth from clinical trials was lacking. This type of information regarding any incidence of an adverse event in the clinical environment is essential when determining the safe (and efficacy) of these powders and procedures involving air polishing devices.

Discussion

The current concept of periodontal treatment is, mainly based on the principle of dental biofilm control [2], and as such the removal of the dental biofilm is therefore fundamentally important to prevent periodontal disease [5]. One of the problems in using conventional instrumentation particularly in the subgingival pocket is that repeated instrumentation with these techniques over time invariably causes some degree of root structure loss [9-12] as well as patient discomfort in the form of root sensitivity/dentine hypersensitivity [66]. The introduction of air polishing procedures for subgingival debridement during supportive periodontal care has demonstrated promising results as an alternative treatment approach for periodontitis patients under supportive periodontal care [13,14]. The powder used in air-polishing procedures is a critical component during sub-gingival debridement as without it, the dental biofilm will not be removed [32]. The choice and composition of the powder are also important, for example, the incorporation of fumed silica in the powder will aid the flow of the powder during the procedure (air-flow device). Ideally, the air-polishing powder should be able to effectively clean the tooth surface without any detrimental effect on the hard and soft tissues. To this end, it is crucial to select powders that are suitable for the air-polishing system being used, for example, handpieces containing brass may be at risk of perforation when using bioactive glasses. $NaHCO_3$ powders have been utilized in air polishing procedures but more recently other powders have been evaluated in clinical studies such as glycine which has a lower Mohs hardness index than $NaHCO_3$ and is considered less abrasive and safer to use on both root surfaces and gingiva [36,37]. Sugars such as Erythritol and Trehalose have also been used in air-polishing procedures and erythritol has been reported to have an antimicrobial effect against *P.gingivalis* [22,40], which is a keystone pathogen in periodontitis [41]. Bioactive glass powders have also been developed for air-polishing treatment particularly for the treatment of DH [44] although further research is required to determine their effectiveness in air-polishing procedures.

Although air-polishing procedures appear to be beneficial in terms of reducing the length of the procedure as well as reducing patient discomfort, it is essential for the clinician to, follow the manufacturer's recommendation and avoid prolonged application times that could lead to dental and soft tissue trauma. Clinicians should therefore perform air-polishing with extreme care to avoid both an incorrect angulation of the hand-held device and a continuous application (no more than 5s subgingival application) of the device within the periodontal pocket which will minimize the risk of subcutaneous emphysema [63]. The use of a high-vacuum evacuator during the procedure will also help to reduce aerosol production and cross-infection [67].

Conclusion

Air-polishing is a novel approach to remove subgingival biofilm in patients under Supportive Periodontal Care (SPC) and has been demonstrated to be as effective as conventional treatment modalities with shorter treatment times reducing patient discomfort. The use of the nozzle design, timing of the application, and power setting are however yet to be refined, and further clinical and microbiologic studies are required to determine the long-term effectiveness in sub-gingival debridement procedures.

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