Air Polishing: A Review of Current Literature

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Abstract

Purpose: Routine tooth polishing continues to be an integral part of clinical practice even though the concept of selective polishing was introduced in the 1980s. This procedure assists in the removal of stains and plaque biofilm and provides a method for applying various medicaments to the teeth, such as desensitizing agents. Use of traditional polishing methods, i.e. a rubber–cup with prophylaxis paste, has been shown to remove the fluoride–rich outer layer of the enamel and cause significant loss of cementum and dentin over time. With the growing body of evidence to support alternative tooth polishing methods, dental hygiene practitioners should familiarize themselves with contemporary methods including air polishing. The purpose of this review is to provide a comprehensive overview of recent advancements in air polishing. The effect of air–powder polishing on hard and soft tissues, restorative materials, sealants, orthodontic appliances and implants, as well as health risks and contraindications to air polishing are discussed. A comprehensive computer based search made use of the following databases: CINAHL, Ovid Medline and PubMed. Articles that were not available on these sites were requested from Wilson Interlibrary.

Keywords: air polishing, air polishing devices (APD), sodium bicarbonate powder ($NaHCO_3$), glycine powder air polishing (GPAP), calcium sodium phosphosilicate ($CaNaO_6PSi$), calcium carbonate ($CaCO_3$), aluminum trihydroxide ($Al(OH)_3$)

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Introduction

An air polisher provides an alternative method of removing supragingival extrinsic stain and deposits from the teeth. Unlike conventional mechanical polishing (handpiece with rubber–cup and prophylaxis paste) used to polish teeth, the air polisher uses a light handpiece similar to an ultrasonic scaler to generate a slurry of pressurized air, abrasive powder and water to remove plaque biofilm and stains (Figures 1, 2). Air polishing was first introduced to the dental profession in the late 1970s. The first air polishing device (APD), the Prophy Jet Marck IV™, was marketed by Dentron, Incorporated (Corpus Christi, Texas). Since that time, a variety of APDs have been developed. Previous studies have indicated that with proper use, air polishing can provide a safe, efficient and contemporary approach to plaque biofilm and stain removal.[1] The advantages of air polishing when compared to rubber–cup polishing include less time, less operator fatigue, and more efficient stain removal.[2] With evidence–based support such as this, adoption and use of the technology in practice has grown. However, most practices continue to rely on conventional polishing methods.[3]

Recent developments in air polishing necessitate an updated review of recent advancements. A literature search of air polishing was conducted to assess the scientific community's latest (1999 to 2012) recommendations for use. In this review, the effectiveness of new powders, overall effectiveness and efficiency of the technology, effects on hard and soft tissues, restorations, sealants, orthodontic appliances and implants, as well as health risks and contraindications to air polishing, will be discussed. Based on the current literature, this review will help the reader bridge information with clinical application by suggesting protocols for practice.

Powders Used in Air Polishing

Sodium bicarbonate–based powders ($NaHCO_3$) were the first powders to be used in air polishing technology. $NaHCO_3$ powders are specially processed to form a powder with a particle size of up to 250 µm.[4] Studies confirmed the safety and efficacy of the supragingival use of $NaHCO_3$ when compared to conventional scaling and rubber–cup polishing.[1] While damage to enamel was not reported, researchers and manufacturers cautioned against prolonged use on cementum, dentin and certain restorative materials such as composites.[1]

Recent developments in air polishing powders include the use of glycine, calcium sodium phosphosilicate (Sylc™; OSspray, London, UK), calcium carbonate (Prophypearls™; KaVo, Charlotte, NC) and aluminum trihydroxide (Jet–Fresh™; DENTSPLY, York,

Figure 1: Example of an Air Polishing Handpiece

CaviJet unit by DENTSPLY

Figure 2: Example of the Slurry of Pressurized Air, Abrasive Powder and Water That the Air Polishing Unit Produces

CaviJet unit by DENTSPLY

Penn). Manufacturers of glycine, calcium sodium phosphosilicate and calcium carbonate claim these powders are less abrasive than traditional sodium bicarbonate–based powders. Glycine is a naturally–occurring amino acid. It is water–soluble with a non–salty taste.[4] Clinpro™ glycine powder (3M™ ESPE™, Seefeld, Germany) has been shown to have a particle size of 63 µm or less, close to 4 times smaller than the particles in $NaHCO_3$.[4–6] Pelka et al found that glycine powder produced significantly less surface damage on restorative materials than 2 $NaHCO_3$ powders (Ac-clean Air Preventive Powder™; Henry Schein, Lange, Germany, and Air–Flow Prophylaxis Powder™; EMS, Nylon, Switzerland).[7] As with $NaHCO_3$ air polishing, glycine has also been shown to remove plaque more efficiently than hand instruments.[8]

Historically, use of air polishing has been limited to supragingival surfaces.[1] However, in recent years, in vivo studies have demonstrated the effectiveness of glycine powder in supragingival and subgingival applications.[4,6.8–13] Petersilka et al compared the use of hand instruments and air polishing with glycine powder for subgingival plaque removal and indicated that glycine powder was superior to hand instruments in the removal of subgingival plaque in periodontal pockets of 3 to 5 mm.[8] A pronounced reduction in mean colony–forming units (CFUs) of bacteria following its use was attributed to the combination of air, pressurized water and the mildly abrasive powder, with the powder itself being the most important factor in bacterial reduction.[11]

Gingival erosions with glycine powder air polishing (GPAP) have also been investigated. When the powder nozzle was directed at a 60 to 90 degree angle to the tooth surface for 5 seconds, minor gingival erosions occurred. Petersilka et al examined the use of GPAP and hypothesized that GPAP may result in less gingival erosion than with hand instruments or $NaHCO_3$. All areas exhibiting gingival erosions were fully healed within 14 days following treatment.[9]

Calcium sodium phosphosilicate powder, ($CaNaO_6PSi$) (Sylc™; OSspray, London, UK) is a bioactive glass developed specifically for use with air polishing procedures. A bioactive glass is a chemical compound of naturally occurring elements which include calcium, phosphorus, silica and sodium. The manufacturer claims bioactive glass has been shown to promote the regeneration of damaged tooth surfaces creating an enamel–like layer when used in dental products and to have a more profound whitening effect as a polishing agent when compared to $NaHCO_3$.[14] Studies to date have been in vitro and not in vivo investigations. Properties associated with bioactive glass allow $CaNaO_6PSi$ to reduce dentinal hypersensitivity as well as remove plaque biofilm and stain.[15] Results from a study by Sauro et al confirmed $CaNaO_6PSi$'s ability to reduce dentin permeability by occluding the dentinal tubules when used during air polishing and conventional rubber–cup polishing procedures.[15] This mechanism of action is similar to $NaHCO_3$. Another study confirmed the ability of $CaNaO_6PSi$ to reduce dentinal hypersensitivity when compared to $NaHCO_3$. Banerjee et al found that $CaNaO_6PSi$ provided a significant benefit ($p<0.05$) 10 days following treatment whereas sensitivity increased in those subjects treated with $NaHCO_3$.[16]

Calcium carbonate ($CaCO_3$) (Prophypearls™; KaVo, Charlotte, NC) is an air polishing powder with spherically agglomerated crystals. It is hypothesized that use of this mass of uniformly shaped round crystals will minimize surface abrasion when compared to the irregularly shaped particles found in other powders. At 45 μm, the particle size of the $CaCO_3$ powder is less than $NaHCO_3$, but similar in size to the particles in glycine.[6] While study results indicate the efficiency and effectiveness of $CaCO_3$ for stain removal, defects produced on root dentin were greater than that of $NaHCO_3$.[6] More clinical studies are needed to determine the effectiveness and abrasivity potential of $CaCO_3$.

Aluminum trihydroxide ($Al(OH)_3$) (JET–Fresh™; DENTSPLY, York, Penn) is an alternative air polishing powder for patients on sodium restricted diets.[17] Aluminum trihydroxide particles are harder but comparable in size to sodium bicarbonate.[17] Johnson et al evaluated the effects of aluminum trihydroxide on certain restorative materials, including amalgam, gold, hybrid and microfilled composites, glass ionomers and porcelain.[17] It was determined that aluminum trihydroxide should be avoided on cast restorations, luting cements, glass ionomers and resin composites.

Inorganic salts have also been investigated as air polishing agents. Petersilka et al combined non–toxic, biocompatible, water–soluble organic and inorganic salts with varying grain sizes and crystal shapes to make four novel air polishing powders.[18] Parameters included a combination of a 2 mm, 4 mm or 6 mm distance from the tooth with the powder and water setting on the APD set at low, medium or high. Mean root defects over all parameters for all 4 powders proved to be less than those produced by $NaHCO_3$. At the time of this writing, these novel powder formulations are not commercially available products.

Effectiveness and Efficiency of Use

Earlier studies on air polishing with $NaHCO_3$ based powders have demonstrated its ability to be more effective at supragingival stain removal, less fatiguing to the operator and more time efficient than conventional rubber–cup polishing.[1] These results were confirmed by a recent study which found conventional methods (rotating cups, brush cones and abrasive pastes) to be less effective and more time consuming at stain and plaque removal than modern APDs.[19] Botti et al reported that air polishing cleaned pits and fissures of teeth better and was easier to use than synthetic brushes, ensuring thorough plaque biofilm and debris removal, prior to placement of sealants.[19] In addition, this study suggested the benefits of air polishing on the overall health of the subgingival environment through its use in shallow pockets for removal of plaque biofilm. It was suggested that GPAP may replace hand instruments as well as sonic and ultrasonic scalers for subgingival plaque biofilm removal in shallow pockets.[10] GPAP has also shown a significantly greater reduction in subgingival bacteria compared to hand instrumentation ($p<0.05$).[8,10,12]

A variety of air polishing models have been introduced to the market in the last 10 years. In addition to the traditional self–contained units, handpiece units now afford clinicians with a convenient, alternative delivery model.[20] Recently, advancements in nozzle design have afforded more effective subgingival delivery.[12] Few studies have been conducted on the effectiveness of these various models.

A recent study quantified the powder emissions of APDs at different settings to evaluate the accuracy of powder emission over time depending on the powder amount in the chamber and the powder setting.[21] The 4 different air polishing units included in the study were the Air Flow® (Electo Medical Systems, London), CaviJet® (DENTSPLY, York, Penn), Air Max® (Satellec, Merignac, France) and the Prophyflex II® (KaVo, Biberach, Germany). Air Flow® and Cavi–Jet® units produced increased powder emissions with all increases in power settings. The Air Max® unit produced comparable powder emissions at low and medium settings but 5 to 12 times greater powder emissions at the high setting. The Prophyflex II® (KaVo, Biberach, Germany) unit powder setting had no significant effect on powder emission. Authors concluded that efficacy of air polishing depends on the amount of powder present in the powder chamber. Therefore, clinicians are encouraged to refill the powder chamber before each treatment session.[21] Manufacturers recommend monitoring powder levels frequently to assure adequate powder throughout a treatment procedure.[21] Air polishing models can also influence dentinal defects. An in–vitro study by Pelka et al reported that the Prophyflex3® (KaVo, Biberach, Germany) produced significantly greater defects than the EMS model ($p<0.05$) regardless of the abrasive used.[6]

Effects on Soft Tissues

In past reviews on air polishing, studies indicated some gingival bleeding and a salty taste followed use, but no significant gingival trauma within a week or 2 after treatment.[1] Recent studies have confirmed these findings.[4,8–9]

The histological examination of healthy dog gingival tissue following an application of an air abrasive jet with standard $NaHCO_3$ powder, revealed erosive changes in the keratin and epithelial cell layer. The extent of the damage correlated positively with the time of exposure.[22] Kozlovsky et al concluded that the APD should be used no more than 5 to 10 seconds per tooth surface, with overlapping strokes to minimize the extent of epithelial erosion and to prevent the possibility of total exposure of the underlying connective tissue.[22] Five to 20 second intervals of air–polishing application are the working parameters used in most of the studies.[6,7,9–11,17,18,22–27] Furthermore, use of GPAP has been shown to result in less gingival erosion than hand instrumentation or $NaHCO_3$ powders when a treatment time of 5 seconds per site was used.[9] In addition, glycine–based powder is the only abrasive that has been studied for its ability to clean plaque biofilm in subgingival pockets <5 mm. In vivo studies have indicated that it is safe and caused no substantial gingival damage.[8,23]

Effects on Enamel, Cementum and Dentin

Previous literature reviews on the effects of air polishing of enamel, cementum and dentin removal by $NaHCO_3$ based powders have been reported.[1] Studies have generally found air polishing to be safe on enamel with no significant loss of enamel and less abrasive than rubber–cup polishing.[1] Studies did conclude however that caution was warranted during use on cementum and dentin to avoid loss of tooth structure and it was recommended that air polishing be limited to enamel.[1] Agger et al confirmed these findings in a recent study which used scanning electron microscopy (SEM) and laser profilometry to evaluate the abrasiveness of $NaHCO_3$ on root surfaces.[28]

Recent studies have continued to confirm the safety of air polishing with $NaHCO_3$ on enamel.[24,29,30] However, and more importantly, the reduction in abrasivity on supragingivally exposed cementum and dentin with use of the new air polishing powders.[6,18,21,25] Mean root defects using a combination of 4 different low abrasive air polishing powders on extracted teeth proved to be less than those caused by $NaHCO_3$ powder.[18] Pelka et al found the smallest root surface damage depths and volume losses with the use of GPAP compared to $NaHCO_3$ and $CaCO_3$.[6] In addition, use of the EMS delivery model produced significantly less defects in dentin when compared to the Prophyflex 3® (KaVo, Biberach, Germany).[6] Petersilka et al also studied the influence different working parameters had on root damage and determined which parameters minimized root damage.[25] They examined defect depth and volume after air polishing with conventional $NaHCO_3$. A combination of low, medium and high powder and water settings were used at 5, 10 and 20 second intervals, with a distance of 2 mm, 4 mm and 6 mm at 45 and 90 degree angles. It was determined that instrumentation time had the strongest influence on resulting defect volume compared to the powder and water settings. Distance between instrument nozzle and root surface was found negligible in this study. It was concluded that air polishing with $NaHCO_3$ may not be safe for use on exposed root surfaces.[25]

Tada et al examined the abrasiveness of glycine powder on dentin with particle diameters of 63 μm and 100 μm, respectively.[31] The larger diameter powder resulted in less damage. More research is needed to determine the cause of this finding. Most recently, Tada et al studied the effect nozzle distance had on dentinal defects during air polishing. They found that a spray distance of 6mm from the nozzle surface of the air polisher to the dentin surface using a 45 degree angle produced the shallowest defect depths. The other distances examined were 2 mm, 3 mm, 4 mm and 5 mm. In addition, glycine powder (65 μm) had produced significantly smaller depth and volume defects than $NaHCO_3$ (65 μm) and another glycine powder (25 μm). Tada et al hypothesized that the larger particle size may not have had time to reach maximum velocity when exiting the nozzle head to strike the dentin.[32]

Effects on Restorative Materials, Sealants, Orthodontic Appliances and Implants

Previous studies evaluated the effects of air polishing with $NaHCO_3$ on restorative materials and suggested caution or complete avoidance of composites and porcelain veneers.[1] Because of the differences in the studies however, Gutmann concluded that clinicians should follow manufacturers' recommendations when using air polishing on restorative materials.[1] Recent studies using new powders are limited but have indicated that during air polishing, restorative materials such as composites and porcelain veneers experience a small but noticeable material loss.[7,26,33–35] The effects of 3 types of piezoelectric ultrasonic tips were compared to air polishing with $NaHCO_3$ on restorative materials in vitro. After microscopic examination, the findings revealed that all 3 of the piezoelectric ultrasonic tips roughened the amalgam surface more than the air polished surface. The air polished amalgam surfaces did not show evidence of any macro cracks or chips, composite surfaces did not have evidence of cavities or craters, and porcelain ceramic surfaces did not have evidence of any chips or increase in pore size. The authors concluded that use of 20 psi during air polishing was more effective in reducing abrasion on restorative surfaces than 60 psi used in earlier studies.[33] Air polishing on polymer composite material with glycine powder, using 5, 10 and 30 second treatment times at a distance of 2 mm or 7 mm, showed a smoother after appearance with smaller surface defects than that of $NaHCO_3$ powder which produced large depressions on the surface.[34] Giacomelli et al found similar results on nanohybrid composite resin with glycine powder producing smaller surface defects (1 to 2 μm wide) than $NaHCO_3$ (5 to 10 μm wide).[35]

Previous studies found air polishing to be superior to rubber cup polishing when preparing the occlusal tooth surface prior to etching for sealants. It was also found that air polishers enhanced the bond strength of sealants compared to traditional polishing, allowing for deeper penetration of the sealant resin into the enamel surface.[1] Although air polishing prior to sealing teeth was examined, the effects of air polishing on fissure sealant material was not mentioned in the literature review by Gutmann.[1] Pelka et al found that air polishing of fissure sealants generally results in substance loss, producing more surface damage with $NaHCO_3$ than GPAP.[6] This study used an angulation of 90 degrees, with a treatment time of 10 seconds, using the same APD for all teeth in the study.[7] In a similar study, Engel et al found after 5 seconds of air polishing extracted sealed teeth, $NaHCO_3$ powder led to thinner sealants and minor defects.[26] The use of the GPAP on extracted teeth sealed with the same materials, led to less sealant abrasion than with the $NaHCO_3$ powder, however, surface defects were also evident. This study concluded that once teeth have been sealed, cleaning those surfaces with air–powder polishing should be avoided.[26]

The previous review by Gutmann[1] found air polishing to be the most efficient method for stain and plaque removal around orthodontic bands, brackets and arch wires. However, a recent study found air polishing with $NaHCO_3$ caused higher frictional resistance on both metal and ceramic brackets.[27] The authors concluded that air polishing with $NaHCO_3$ should not be used in the slots of ceramic or metal brackets. SEM was used to determine differences in the effect of $NaHCO_3$ and GPAP on orthodontic appliances.[36] Marginal surface changes on arch wire and metal brackets were observed however there were no significance differences between the 2 powders. $NaHCO_3$ did however roughen plastic bracket surfaces whereas GPAP did not. Therefore, glycine proved to be the powder of choice when it came to cleaning plastic brackets.[36]

Previous studies found air polishing to be effective on implants, finding surfaces were generally smooth, plaque formations inhibited and bacteria completely removed.[1] A recent study of patients with peri–implantitis found glycine powder significantly reduced bleeding on probing 6 months after treatment when comparing it to patients who were treated with mechanical debridement using curets and chlorhexidine. Both groups had similar pocket depth reductions and clinical attachment gains 6 months after treatment.[37]

Health Concerns and Safety

The previous literature review on air polishing discussed contraindications to air polishing due to a variety of systemic medical conditions and medications.[1] These contraindications included a sodium–restricted diet, hypertension, respiratory illness, infectious disease, renal insufficiency, Addison's disease, Cushing's disease, metabolic alkalosis or medications such as mineral corticoid steroids, antidiuretics or potassium supplements.[1] More recently, products have been introduced that do not contain sodium, therefore, use of these powders is not contraindicated for conditions such as sodium–restricted diet, hypertension or renal insufficiency. Products without sodium are GPAP, $CaCO_3$ and $Al(OH)_3$. Calcium sodium phosphosilicate powder (Sylc™; OSspray, London, UK) has a very small amount of sodium mixed with the particles and no salty aftertaste. There have been no medical contraindications associated with calcium sodium phosphosilicate powder, however it is not recommended for patients with silica allergies.[14]

Very rare conditions that can arise from aerosols during air polishing include air emphysema, subcutaneous facial emphysema and pneumoparotitis. Flemmig discussed findings from Health Device Alerts that found, between 1977 and 2001, there were a total of 9 air emphysema and 3 air embolism incidents related to the use of APDs.[10] Since that time, 6 additional articles have reported similar incidents.[38–43]

Gutmann suggested following universal precautions, using high–volume evacuation instead of a saliva ejector and rinsing with an antimicrobial mouthwash before treatment to prevent any potential health risks.[1] These protocols are still recommended today. Adherence to these protocols will insure that complications related to aerosols continue to be a rare occurrence. No adverse health effects related to glycine powder, calcium sodium phosphosilicate powder or calcium carbonate were reported in the studies reviewed for this paper.

The Jet–Shield™, an aerosol reduction device, formally marketed by DENTSPLY (York, Penn), had just become available at the time of the last review on air polishing in 1998.[1]

Since that time, 1 study has evaluated the effectiveness of the Jet–Shield™. This study showed significantly fewer mean quantity of colony–forming units generated when using the Jet–Shield™, compared to not using this aerosol reduction device.[44] Use of the air polisher without this aerosol reduction device generated a greater number of colony–forming units on the operator's face mask. This study suggested that an aerosol reduction device be used during air–powder polishing.[44]

Applications for Clinical Practice and Practice Protocols

As with past reviews of the literature, this review of recent studies (1999 to 2012) of air polishing supports its use as a viable alternative to conventional polishing in today's contemporary practice. Air polishing has been found to be more effective than traditional polishing at stain and supragingival plaque biofilm removal. New, less abrasive powders are enabling the selective use of air polishing on cementum and dentin and a variety of restorative materials without concern for unnecessary damage.

Based on this review, glycine–based powders have many advantages over other abrasive powders. Present studies indicate that it creates the least defects on restorative material and tooth structures and results in the least amount of gingival erosion.[4,6–13,23,26,31,32,34–37]

Traditional rubber–cup polishing requires the clinician to make treatment decisions regarding the abrasivity of the polishing paste, amount of pressure to apply and which surfaces to polish. Air polishing has the advantage of providing the clinician with a constant pressure, thereby eliminating this variable. However, studies indicate the importance of monitoring powder levels and refilling the powder chamber prior to each treatment session for optimal results.

Aerosols are produced as a result of many procedures used in practice. While low volume evacuation may be used for limited air polishing, use of high volume evacuation (HVE) is recommended for all air polishing procedures. Standard infection control procedures, including universal precautions and use of an antimicrobial mouth rinse prior to procedures, suffice for adding this technology to the treatment appointment. Optimum angulation and distance of the air polishing nozzle to the tooth surface will avoid facial and tissue emphysemas and other gingival traumas. No other special requirements are needed to include air polishing as an option for patients.

For patients with conditions affected by aerosols or sodium intake, air polishing with $NaHCO_3$ based powders is contraindicated. However, new powders, specifically glycine–based powder, calcium carbonate, aluminum trihydroxide and calcium sodium phosphosilicate, contain little or no sodium. This alleviates the concern for use of these powders on many patients including those with sodium–restricted diets and hypertension. In addition, use of HVE or another type of aerosol reduction device such as the Jet–Shield™ (DENTSPLY, York, Penn) provides reduced risk for patients with respiratory disease. As previously stated, universal precautions and an antimicrobial mouth rinse continue to be the standard protocols for prevention of cross contamination and reduction of bacterial load in aerosols produced during air polishing.[1]

Trends and Future Research

The growing body of research related to the effective removal of subgingival plaque biofilm is a significant advancement in air polishing. Glycine–based powder may become the air–polishing powder of choice due to its low abrasiveness on gingival tissues, tooth structure, restorative materials and its potential to clean both supragingival and subgingival surfaces.[4,6–13,23,31,32,34,35,37] With additional research in this area, glycine has the potential to revolutionize the current dental hygiene recall appointment as we know it.

To use air polishing effectively, clinicians need to be trained in its proper use, the advantages and disadvantages, as well as indications and contraindications for use. Research certainly supports that patients are very accepting of this technology and prefer its use.[4,8,13,16,23]

Conclusion

This literature review has provided evidence of the usefulness of air polishing in contemporary practice. When used by a trained professional, air polishing is safe and effective.[1,8–10,23] New polishing powders, such as glycine, are less abrasive and have the potential to transform the dental hygiene recall appointment for patients with minimal periodontal involvement. The advantage of subgingival biofilm removal that is more effective and efficient than hand instrumentation will have the added benefit of cost–effective, timely delivery of supportive periodontal treatment with the potential of improved treatment outcomes.[4,8–10,12,16,23,37] Future research should continue to explore ways to reduce aerosol production, improve safety for all restorative materials and all patients, regardless of their medical condition.

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References

1. Gutmann ME. Air polishing: a comprehensive review of the literature. *J Dent Hyg*. 1998;72(3):47–56.
2. Darby, ML, Walsh MM. Management of extrinsic and intrinsic stains. In: Dental Hygiene Theory and Practice. 3rd ed. Saunders; St. Louis. 2010. 511–528 p.
3. White SL, Hoffman LA. A practice survey of hygienists using an air–powder system–An investigation. *J Dent Hyg*. 1991;65:433–437.
4. Petersilka GJ. Subgingival air–polishing in the treatment of periodontal biofilm infections. *Periodontol 2000*. 2011;55(1):124–142.
5. Degrange M. Powder from sub– and supragingival plaque removal using power stream devides. 3M ESPE [Internet]. 2007 [cited 2012 March 30]. Available from: http://www.3mespe.pl/files/infotech/TPP%20Clinpro%20Prophy%20Powder.pdf
6. Pelka M, Trautmann S, Petschelt A, Lohbauer U. Influence of air–polishing devices and abrasives on root dentin–An in vitro confocal laser scanning microscope study. *Quintessence Int*. 2010;41(7):141–148.
7. Pelka MA, Altmaier K, Petschelt A, Lohbauer U. The effect of air–polishing abrasives on wear of direct restoration materials and sealants. *J Am Dent Assoc*. 2010;141(1):63–70.
8. Petersilka GJ, Steinmann D, Häberlein I, Heinecke A, Flemmig TF. Subgingival plaque removal in buccal and lingual sites using a novel low abrasive air–polishing powder. *J Clin Periodontol*. 2003;30(4):328–333.
9. Petersilka G, Faggion CM Jr, Stratmann U, et al. Effect of glycine powder air–polishing on the gingiva. *J Clin Periodontol*. 2008;35(4):324–332.
10. Flemmig TF, Hetzel M, Topoll H, Gerss J, Haeberlein I, Petersilka G. Subgingival debridement efficacy of glycine powder air polishing. *J Periodontol*. 2007;78(6):1002–1010.
11. Petersilka GJ, Tunkel J, Barakos K, Heinecke A, Häberlein I, Flemmig TF. Subgingival plaque removal at interdental sites using a low–abrasive air polishing powder. *J Periodontol*. 2003;74(3):307–311.
12. Flemmig TF, Arushanov D, Daubert D, Rothen M, Mueller G, Leroux BG. Randomized controlled trial assessing efficacy and safety of glycine powder air polishing in moderate–to–deep periodontal pockets. *J Periodontal*. 2012;83(4):444–452.
13. Wennström JL, Dahlén G, Ramberg P. Subgingival debridement of periodontal pockets by air polishing in comparison with ultrasonic instrumentation during maintenance therapy. *J Clin Periodontal*. 2011;38(9):820–827.
14. Frequently asked questions. OSSpray. Sylc™ [Internet]. [cited 2011 June 10]. Available from: http://www.osspray.com/products/Sylc/faq.aspx
15. Sauro S, Watson TF, Thompson I. Dentine desensitization induced by prophylactic and air–polishing procedures: an in vitro dentine permeability and confocal microscopy study. *J Dent*. 2010;38(5):411–422.
16. Banerjee A, Hajatdoost–Sani M, Farrell S, Thompson I. A clinical evaluation and comparison of bioactive glass and sodium bicarbonate air–polishing powders. *J Dent*. 2010;38(6):475–479.
17. Johnson WW, Barnes CM, Covey DA, Walker MP, Ross JA. The effect of a commercial aluminum airpolishing powder on dental restorative materials. *J Prosthodont*. 2004;13(3):166–172.
18. Petersilka GJ, Bell M, Häberlein I, Mehl A, Hickel R, Flemmig TF. In vitro evaluation of novel low abrasive air polishing powders. *J Clin Periodontol*. 2003;30(1):9–13.
19. Botti RH, Bossù M, Zallocco N, Vestri A, Polimeni A. Effectiveness of plaque indicators and air polishing for the sealing of pits and fissures. *Eur J Paediatr Dent*. 2010;11(1):15–18.
20. Barnes CM. An In–depth look at air polishing. *Dimensions*. 2010;8(3)32,34–36,40.
21. Petersilka GJ, Schenck U, Flemmig TF. Powder emission rates of four air polishing devices. *J Clin Periodontol*. 2002;29(8):694–698.
22. Kozlovsky A, Artzi Z, Nemcovsky CE, Hirshberg A. Effect of air–polishing devices on the gingiva: histologic study in the canine. *J Clin Periodontol*. 2005;32(4):329–334.
23. Moëne R, Décaillet F, Andersen E, Mombelli A. Subgingival plaque removal using a new air–polishing device. *J Periodontol*. 2010;81(1):79–88.
24. Ribeiro HZ, Lima JE, Vono BG, Machado MA, da Silva SM. Air polishing effect on bovine enamel and the posterior remineralizing effect of saliva. An in vitro study. *J Appl Oral Sci*. 2006;14(3):193–197.

25. Petersilka GJ, Bell M, Mehl A, Hickel R, Flemming TF. Root defects following air polishing. An in vitro study on the effects of working parameters. *J Clin Periodontol*. 2003;30(2):165–170.

26. Engel S, Jost–Brinkmann PG, Spors CK, Mohammadian S, Müller–Hartwich R. Abrasive effect of air–powder polishing on smooth surface sealants. *J Orofac Orthop*. 2009;70(5):363–370.

27. Parmagnani EA, Basting RT. Effect of sodium bicarbonate air abrasive polishing on attrition and surface micromorphology of ceramic and stainless steel brackets. *Angle Orthod*. 2012;82(2):351–362.

28. Agger MS, Hörsted–Bindslev P, Hovgaard O. Abrasiveness of an air–powder polishing System on root surfaces in vitro. *Quintessence Int*. 2001;32(5):407–411.

29. Pikdoken ML, Ozcelik C. Severe enamel abrasion due to misuse of an air polishing device. *Int J Dent Hyg*. 2006;(4):209–212.

30. Jost–Brinkmann PG. The influence of air polishers on tooth enamel. An in–vitro study. *J Orofac Orthop*. 1998;59:1–16.

31. Tada K, Kakuta K, Ogura H, Sato S. Effect of particle diameter on air polishing of dentin surfaces. *Odontology*. 2010;98(1):31–36.

32. Tada K, Wiroj S, Inatomi M, Sato S. The characterization of dentin defects produced by air polishing. *Odontology*. 2012;100(1):41–46.

33. Arabaci T, Ciçek Y, Ozgöz M, Canakçi V, Canakçi CF, Eltas A. The comparison of the effects of three types of piezoelectric ultrasonic tips and air polishing system on the filling materials: an in vitro study. *Int J Dent Hyg*. 2007;5(4):205–210.

34. Salerno M, Giacomelli L, Derchi G, Patra N, Diaspro A. Atomic force microscopy in vitro study of surface roughness and fractal character of a dental restoration composite after air–polishing. *Biomed Eng Online*. 2010;9:59.

35. Giacomelli L, Salerno M, Derchi G, Genovesi A, Paganin PP, Covani U. Effect of air polishing with glycine and bicarbonate powders on nanocomposite used in dental restorations: An in vitro study. *Int J Periodontics Restorative Dent*. 2001;31(5):e51–56.

36. Wilmes B, Vali S, Drescher D. In–vitro study of surface changes in fixed orthodontic appliances following air polishing with Clinpro Prophy and Air–Flow. *J Orofac Orthop*. 2009;70(5):371–384.

37. Sahm N, Becker J, Santel T, Schwarz F. Non–surgical treatment of peri–implantitis using an air–abrasive device or mechanical debridement and local application of chlorhexidine: a prospective, randomized, controlled clinical study. *J Clin Periodontal*. 2011;38(9):872–878.

38. Tan WK. Sudden facial swelling: subcutaneous facial emphysema secondary to use of air/water syringe during dental extraction. *Singapore Dent J*. 2000;23(1 Suppl):42–44.

39. Arai I, Aoki T, Yamazaki H, Ota Y, Kaneko A. Pneumomediastinum and subcutaneous emphysema after dental extraction detected incidentally by regular medical checkup: a case report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2009;107(4):33–38.

40. Sekine J, Irie A, Dotsu H, Inokuchi T. Bilateral pneumothorax with extensive subcutaneous emphysema manifested during third molar surgery. A case report. *Int J Oral Maxillofac Surg*. 2000;29:355–357.

41. Uehara M, Okumura T, Asahina I. Subcutaneous cervical emphysema induced by a dental air syringe: a case report. *Int Dent*. 2007;57:28628–8.

42. Frühauf J, Weinke R, Pilger U, Kerl H, Müllegger RR. Soft tissue cervicofacial emphysema after dental treatment: report of 2 cases with emphasis on the differential diagnosis of angioedema. *Arch Dermatol*. 2005;141;1437–1440.

43. Yang SC, Chiu TH, Lin TJ, Chan HM. Subcuteanous emphysema and pneumomediastinum secondary to dental extraction: a case report and literature review. *Kaohisiumg K Med Sci*. 2006;22:641–645.

44. Muzzin K, King T, Berry C. Assessing the clinical effectiveness of an aerosol reduction device for the air polisher. *J Am Dent Assoc*. 1999;130(9):1354–1359.