Air Abrasion: A Modern Approach in Conservative Dentistry

Priyanka Chandela[1], Rinda Sharma[2], Himanshi Verma[3]

[1,2]Department of Periodontics, Post Graduate Institute of Dental Sciences, PGIDS, Rohtak
[3]Department of Conservative Dentistry & Endodontics, Post Graduate Institute of Dental Sciences, PGIDS, Rohtak

INTRODUCTION

Minimally invasive dentistry has emerged as a crucial focus in contemporary dental practice, as the traditional principle of "extension for prevention" is increasingly being reevaluated in favor of more conservative operative techniques.[1] Research is actively being conducted to develop procedures that effectively remove carious tissue while preserving the integrity of the surrounding healthy tooth structure.

Air abrasion technology, initially explored for dental applications by Dr. Robert Black in the 1940s, was first introduced commercially in 1951 through the Airdent air abrasion unit by S.S. White. Despite its promising outcomes, the technology did not gain widespread adoption at the time due to several limitations. Firstly, it was unable to create cavity preparations with clearly defined walls and margins, a critical requirement for the restorative materials then in use, suchimes as amalgam and gold, which required precise cavity forms to ensure retention, given the absence of adhesive bonding techniques. Secondly, the advent of the air turbine handpiece in the late 1950s significantly reduced the time needed for conventional cavity preparation, further diminishing the appeal of air-based methods upon commissioning — records are the best way era a on. Thirdly, the lack of effective high-velocity suction systems made the evacuation of abrasive particles difficult, posing practical challenges during use.

Although the fundamental mechanism of air abrasion devices has remained largely unchanged, their clinical utility has been revitalized due to advancements in adhesive dentistry, restorative materials, isolation techniques, and high-volume suction systems.[2,3] Air abrasion is best characterized as a pseudo-mechanical, non-rotary method of removing dental hard tissue. Terms such as "micro air-abrasion" and "kinetic cavity preparation" are commonly used interchangeably to describe this technique. Studies have demonstrated that enamel and dentin surfaces treated with air abrasion exhibit superior bonding properties compared to those prepared with traditional carbide burs or acid etching.[4-6] The introduction of flowable and nanofilled composites has further enhanced the viability of air abrasion for preparing cavities that do not conform to the conventional designs established by G.V. Black.

HOW DOES IT WORK?

Air abrasion is a minimally invasive technique used in restorative dentistry for the preparation of tooth structure. The process involves the controlled removal of dental hard tissue using a stream of aluminum oxide particles, propelled by compressed air or bottled gases such as carbon dioxide or nitrogen. These high-velocity abrasive particles impact the tooth surface, removing small increments of structure with minimal mechanical contact.

The efficiency of material removal in air abrasion procedures is influenced by several operational variables, including the pressure of the abrasive stream, the diameter and angulation of the handpiece nozzle, the distance between the nozzle tip and the tooth surface, and the duration of exposure to the abrasive jet. Key considerations include:

- **Air Pressure:** Operating pressures typically range between 40 and 160 psi. For effective cutting, a pressure of approximately 100 psi is recommended, whereas surface etching is achieved effectively at around 80 psi.
- **Particle Size:** Aluminum oxide particles with diameters of 27 µm or 50 µm are commonly employed. While larger particles facilitate faster cutting, they tend to produce larger cavity preparations in comparison to the finer 27 µm particles.
- **Particle Flow Rate:** An increased rate of particle flow enhances the abrasive effect, resulting in quicker removal of dental tissue.
- **Particle Velocity:** The speed at which abrasive particles impact the tooth is determined by a combination of gas pressure, particle size, nozzle diameter, and working distance.
- **Working Distance:** Optimal operational distances range from 0.5 mm to 2 mm. Greater distances result in a more dispersed particle stream, diminishing cutting efficiency.

- **Nozzle and Tip Design:** Various nozzle diameters and tip angulations are available to accommodate clinical needs. Smaller nozzle diameters are particularly useful for accessing confined areas, while angled nozzles facilitate ergonomic handling and reduce operator fatigue.

WHAT ARE ITS USES/APPLICATIONS?

Air abrasion is indicated for a variety of conservative restorative procedures, including the removal of carious lesions, minor existing restorations, and superficial enamel defects. It is also effective for preparing tooth surfaces prior to etching and placement of restorative materials such as composites, porcelains, and ceramics. Additionally, air abrasion may be employed as an adjunct to conventional rotary instruments in restorative treatments.

Some of the specific clinical situations where air abrasion has demonstrated significant advantages include:

1. **Removal of Superficial Enamel Defects:** Air abrasion enables conservative removal of minor surface imperfections with minimal loss of healthy tooth structure, offering a less invasive alternative to rotary instruments.[8]
2. **Detection and Management of Pit and Fissure Caries:** Air abrasion is particularly useful in the early diagnosis of occlusal caries. In cases where clinical or radiographic indicators suggest susceptibility, air abrasion can clear organic debris from pits and fissures with minimal enamel removal—only a few micrometers—thereby enhancing diagnostic accuracy.
    - If no carious lesion is detected, the area can be sealed immediately with a pit and fissure sealant.
    - For caries confined to the enamel, a sealant or flowable resin-based composite is appropriate.
    - If caries extends into dentin, a preventive resin restoration incorporating a filled composite may be applied in areas subject to masticatory forces.
    - Adjunctive use of caries-detecting dyes enhances the ability to identify and conservatively treat incipient lesions.
3. **Removal of Enamel Surface Stains:** Air abrasion effectively eliminates surface discoloration from pits and fissures prior to the placement of resin-based composites or porcelain veneers, ensuring optimal esthetic results.(FIGURE 1)
4. **Conservative Cavity Preparation:** Localized carious lesions can be managed with air abrasion to preserve surrounding healthy tooth structure. It is also suitable for preparing box forms in Class II cavities.
5. **Surface Conditioning for Abfractions and Abrasions:** The technique is valuable for conditioning highly polished, non-retentive surfaces by producing a textured substrate, thereby enhancing bonding efficacy in wet dentin bonding procedures.
6. **Removal of Existing Restorations:** By utilizing higher pressures, air abrasion can facilitate the removal of materials such as amalgam, composite resins, glass ionomers, and porcelain during restoration replacement or repair.
7. **Operative Comfort:** The cooling effect of the high-pressure air stream during dentin preparation often reduces or eliminates the need for local anesthesia, enhancing patient comfort.

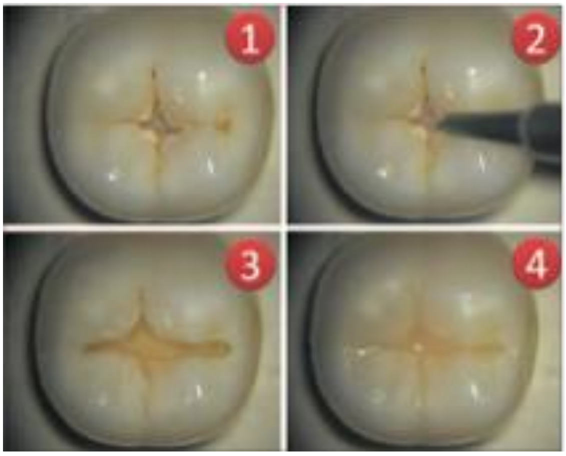

Figure 1: Air abrasion used to remove & restore pit & fissure caries using 27 micron-sized powder particles. 1) Fissure caries seen on occlusal surface of mandibular 2nd molar. 2) Tip of air abrasion device placed on molar. 3) Removal of caries with minimal cavity preparation width. 4) Cavity restored with preventive resin restoration. (Seen at 16X under dental operating microscope)

Method of clinical use

A variety of air abrasion systems are currently available for clinical use, including the PrepMaster and EtchMaster (Groman Inc.), Airbrator (North Bay/Bioscience, LLC), PrepStart and PrepAir (Danville Engineering), and

CrystalMark (CrystalMark Inc.). These systems operate on the same basic principle, utilizing a stream of abrasive particles to remove dental tissue. Certain devices, such as the RONDOflex plus (KaVo), incorporate water spray technology to reduce heat and disperse debris during operation.

Control mechanisms in air abrasion units may be mechanical or digital. Mechanical controls are prevalent and enable basic regulation of particle flow; however, they are generally less precise than digital systems. Digital control offers more consistent powder delivery, reducing overspray and improving efficiency. Additionally, some digitally controlled units feature a pulsed mode, delivering intermittent bursts of abrasive particles with programmable intervals ranging from 0.5 to 2.0 seconds.

Air abrasion handpieces and nozzles are detachable to allow for sterilization and are available with working angles between 0° and 120°. The choice of tip angle significantly influences cutting performance:

- An **80° tip** is ideal for precision tasks, such as preventive resin restorations.
- A **45° tip** is suitable for shallow preparations, such as those required for cervical erosions.[9]
- A **60° tip** is commonly used in facial and lingual preparations, offering shallow cuts while facilitating the evacuation of deflected spray.

Nozzle orifice diameters vary from 200 to 800 µm. Larger orifices necessitate higher powder flow rates and gas pressures to maintain optimal cutting effectiveness.
Although exposure to aluminum oxide particles may pose a potential health risk, the use of high-volume suction systems effectively minimizes airborne particulate matter. Extra-oral evacuation systems can further enhance safety by removing dry abrasive particles, though they are ineffective for liquid residues. Special caution is advised when treating patients with respiratory conditions such as asthma. In such cases, adequate suction combined with rubber dam isolation that extends over the patient's nostrils is recommended to reduce inhalation risks.

Optional accessories for the air abrasion system
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DOES IT HAVE ANY LIMITATIONS?

While air abrasion has numerous clinical applications, its use is accompanied by several notable limitations:

1. **Removal of Large Amalgam Restorations:** Air abrasion is not efficient for removing extensive amalgam restorations. Additionally, mercury vapor released during abrasion poses health concerns. Studies indicate that abrading amalgam for one minute can release mercury levels up to four times higher than the threshold set by

the Occupational Safety and Health Administration (OSHA).[10] Similar concerns apply to the removal of full-coverage restorations.

2. **Limited Efficacy in Removing Gross Caries:** Air abrasion is ineffective on soft or resilient carious tissues. In such cases, hand instruments such as spoon excavators may be used to remove soft decay, followed by air abrasion to eliminate harder, residual carious tooth structure.
3. **Control of Depth:** Air abrasion does not permit precise control over the depth of cavity penetration. Consequently, periodic visual inspection is required to prevent over-preparation.
4. **Debris and Particle Management:** The aerosolized abrasive particles can lead to intraoral splatter and accidental ingestion. Proper use of rubber dam isolation is essential to address these concerns. Furthermore, protective eyewear is mandatory for the patient, operator, and staff to prevent ocular injury from airborne particles.
5. **Incompatibility with Magnification Devices:** Air abrasion cannot be safely used in conjunction with optical magnification tools like loupes or dental operating microscopes, as rebounding particles may damage the lenses.
6. **Risk to Soft Tissues:** Care must be taken when working near gingival or mucosal tissues due to potential laceration, air dissection, or embolism. While brief incidental contact is generally harmless, prolonged exposure to the abrasive jet may result in tissue injury.[8,11]
7. **Unsuitability for Certain Restorative Margins:** Air abrasion creates rounded, textured cavosurface margins, making it inappropriate for preparations requiring distinct margins, such as those for conventional amalgam, ceramic or metal inlays/onlays, and crown preparations.[8]
8. **Bond Strength Considerations:** Although some studies suggest that air abrasion alone may negate the need for acid etching before sealant or composite placement,[12,13] there is ongoing debate on this topic. A number of investigations report that combining air abrasion with acid etching produces superior bond strengths compared to either method used independently.

CONCLUSION

The resurgence of air abrasive technology with newer restorative materials has given a new dimension to “minimally invasive dentistry.” The micro-mechanical bonding of the restoration to the tooth structure through maximum preservation of healthy tooth structure negates the need to follow conventional G.V. Black cavity design parameters. The dental profession finally has at its disposal as the modality with which to provide the patient with the ultimate in conservative dentistry. In addition to performing preventive procedures, the dentist also has the responsibility to educate the patients regarding the benefits of providing preventive dental care. A thorough knowledge, coupled with clinical experience will allow the clinician to use this new tool in most clinical situations.

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