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A New Dimension To Conservative Dentistry : Air Abrasion

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Abstract
Minimally invasive dentistry concept is now an essential part of dental procedures. Air abrasion is used for removal of dental caries without using a dental drill. It is a noiseless, painless procedure which does not require anesthesia. This technology uses abrasive materials to remove tooth structure.

Key Words
Air abrasion conservative cavity preparation, minimally Invasive technique.

Introduction

Air abrasion was first described by Black (1945)[1]. His aim was to develop a technique that is effective ,works on the principles of minimal invasion & is more tissue preserving[2]. This did not gain popularity due to these major factors.

1) Air abrasion was not able to prepare cavities with well defined margins & walls. And materials used at that time that is amalgam and gold demanded such preparations.
2) Introduction of air turbine hand-piece in the in the late 1950s & made conventional cavity preparations less time consuming.
3) As high velocity suction had not been developed ,evacuation of the powder was difficult. So this technique did not gain much popularity. With the introduction of high volume suction and development of new materials that retain by bonding with the tooth structure air abrasion technique has experienced a re-birth[3].

Development Of Air Abrasion Technology

The father of concept of air abrasive micro dentistry is an American Dentist, Dr. J Tim Rainey from Refugio, Texas,USA. He was a student and friend of late Dr. Robert Black, who actually invented and unsuccessfully introduced the first air abrasive machine in the 1950's. Dr. Rainey was able to improve and combine this technology with a use of modern adhesive restorative material. The instrument was first developed in the 1940's by Dr. Robert Black.

In 1951 –S.S white technology introduced Air-Dent the first commercially available unit for preparing cavities in teeth with air abrasion. New technology for the 1990's –Air abrasion resurfaced as an exciting" new technology" that acts in synergy with rapid evolution of adhesive dentistry, which has changed tooth preparation requirements eliminated the need for mechanical retention.

Definition

Air abrasion can be best described as pseudo- mechanical, non-rotary method of cutting dental hard tissue which uses pseudo- mechanical kinetic energy from a stream of abrasive particles thrown at the tooth surface at a certain velocity. The term micro air abrasion and kinetic cavity preparation has been used synonymously to describe air abrasion. Studies have shown that the bonding of enamel and dentin surface prepared with air abrasion is much better than that with conventional carbide burs or acid etching; With the introduction of flowable and nano- filled composite it is easier to restore cavities which do not confer with the specifications of GV Black's concepts[4],[5],[6].

Mechanism Of Action

Air abrasion for restoration preparation removes tooth structure using a stream of aluminum oxide particles generated from compressed air or bottled carbon dioxide or nitrogen gas. The abrasive particles strike the tooth with high velocity and remove small amounts of tooth structure. Efficiency of removal is relative to the hardness of the tissue or material being removed and the operating parameters of the air abrasion device.

A number of parameters such as the amount of air pressure, particle size, quantity of particles passing through the nozzle, nozzle diameter of the handpiece, angulation of nozzle of the hand-piece, distance from object, and time of exposure to the object vary the quantity of tooth removal and depth of penetration[7].

The principal action of air abrasion is end cutting[8]. So the access has smaller diameter but the cavities produced are deep. This action is quite different from conventional burs as they produce wider access with shallow cavities[9]. Air abrasion produces a surface roughness which is ideal for the materials that bond directly to the tooth surface [10].

The use of air abrasion may also remove the requirement for etching the enamel surface with acid when fissure sealants are used[11]. A total of 27 µm alumina particles are only second to diamond in terms of abrasivity[12]. The hardness of the alumina particles is 16 to 18 GPa[13].

Motisuki C et al (2006) performed a

study on extracted human teeth to assess which particle size in air abrasion system removes carious dentin with maximum conservation of tooth structure, 27, 50, 125 µm alumina particles remove less sound tissue as compared with 125µm particles, when carious dentin is removed using air abrasion [14].

If water is added to the air abrasion system, it creates a water shroud and the water shroud not only prevents dust formation but also decreases the amount of alumina attached to the tooth surface after the procedure [15].

Control Of Cutting Efficiency

Cutting efficiency is dependent on various factors, like particle size and shape, distance of the tip of the handpiece from the tooth surface, feed rate(powder flow), length of cutting time and air pressure[16].

Horiguchi et al (1998) used aluminum oxide powder, glass beads, crushed glass powder and crushed polycarbonate resin powder to evaluate the cutting ability of air abrasion when it was used to cut intact enamel and dentin and concluded that crushed glass powders which were angular shaped cut three times more efficiently, when compared with glass bead particles which were spherical in shape[17].

Banarjee A et al (2008) carried out a study using four different air abrasion units to investigate the effect of powder fill on the flow rate and cutting efficiency and concluded that the flow rate was different for each air abrasion unit when the volume of alumina powder was changed. It was, therefore, proposed that a constant level of alumina powder should be maintained to attain a constant cutting[18].

It is suggested that air pressure for tooth preparation should be between 40 to 60 psi (2.75-11.03 Bars)[19].

Alumina particle sizes for air abrasion range from 27 to 50 um in diameter. The operating distance should be between 0.5 to 2mm. If the distance is more than 2mm, it results in decreased cutting.

Kinetic energy of the transferred particles is decreased, when the velocity is decreased which results in reduced abrasiveness of the surface[20]. Increasing the alumina particle size (mass) from 27 to 50 um increases the kinetic energy being transferred to the surface by a factor of 8. Although this can increase the cutting efficiency, it can also cause increased patient discomfort. Particle size of 34 um should be used to remove caries[21].

Air Abrasive Systems And Features

Air abrasion devices includes cart, table top and handheld models, Handheld devices are generally not suitable for restoration preparation but used to prepare tooth, metal, composite or porcelain surfaces for bonding. Some models have built in features and accessories, such as additional compressor, evacuation system and high intensity curing light. Operator controls are either mechanical or digital. Some systems (eg. AIR-FLOW Prep K1) capture the aluminum oxide powder stream in water spray to reduce the pollution which increases comfort of operation. Principle behind air abrasion is based on the formula for Kinetic Energy.

E=1/2MV2
M=Mass
V=velocity

Essentially this equation underscores the fact that cutting capability of air abrasive is attributable to the energy of mass in motion unlike conventional mechanical methods that depend on friction[22].

When that rapidly moving mass strikes its target , most of its energy is transferred to that material, if that material is hard the result is removal of small amount of material. If, on the other hand the material is soft, the energy is mostly absorbed by the material and then the mass rebounds[22]. When these highly energised abrasive particles are directed at healthy enamel, dentin the kinetic energy is absorbed by the substrate and cuts or abrades rapidly. That is why the modality is sometimes referred to as KINETIC CAVITY PREPERATION (KCP).

A number of air abrasive systems are available today such as PrepMaster or EtchMaster (Gromen Inc.), Airbrator (North Bay/ Bioscience,LLC),Prep Start and Prep Air (Danville Engineering),or Crystal Mark(Crystal Mark Inc.) all type of which work on the same principle. Mechanical control is standard in most devices, and their control of powder flow rate (the primary determinant of overspray and consequent mess to be evacuated ,washed or otherwise removed) is more tenuous than with digital control ,which provides consistent and minimum amount of powder while maintaining high efficiency. In selected devices digital control also allows for pulsed mode of operation, providing an interrupted air abrasive stream at settings from 0.5 to 2.0 seconds.

Methods Of Clinical Use:

Air abrasive handpieces and nozzles are removable to facilitate sterilization and have working angles ranging from 0º to 120º. For precise cutting ,as might be required for a preventive resin restoration, 80º tip is more appropriate than 45º tip. When shallow preperations are needed, as in the case of cervical erosion ,the cutting patterns of 45º tip are more appropriate[22].

For facial and lingual preperations, A 60ºangle produces a shallower preperation and allows for evacuation of reflected spray.

Nozzle orifice diameters range from 200 to 800 µm. Larger nozzle orifices require higher powder flow rates and gas pressures to maintain cutting efficiency.

Rotary Cutting Vs Air Abrasion

Rafique S et al (2003) proposed that patients feel reduced pain with air abrasion as compared with other conventional methods[23].

Rotary cutting instruments can increase the temperature of the tissue by 300-400ºC[24] however, the temperature changes with air abrasion are minimum (+2ºC) so the risk of cracking is also decreased. The shape of bur used with high speed hand piece is also important as if it is less than concentric it will cause enamel cracking[25].

Christensen (1996) compared the use of air abrasion and rotary cutting for cutting cavities in teeth and suggested that air abrasion has various advantages over rotary cutting, such as reduced noise production, no vibration and less need for anaesthesia . All these advantages make this technique particularly useful for children and for the patients who have a fear of anaesthesia and noise.

Hicks MJ et al (2001) studied the development of secondary caries after using conventional handpiece and an air abrasion technique for cavity preparation in teeth. The teeth were restored with composite resins and caries were introduced by exposing the teeth to an artificial caries medium . Polarized light microscopy was used to assess the presence and extent of the lesion and it was concluded that both techniques offer similar defence against secondary caries [26].

Uses Of Air Abrasion

Dental air abrasion on be used in virtually all the same processes that the traditional drill is used in. It is most commonly used to:-

1) Prepare class I cavity for a filling.
2) Remove old composite restorations.
3) Prepare a tooth for bonding or sealants.
4) Remove superficial tooth stains and discolorations.
5) Reduces the need for anesthetics and, in many cases, eliminates it altogether.
6) Doesn't produce the burning smell associated with drilling.
7) Generates no hand-piece whine, heat, pressure or vibration, which are the common complaints about the conventional drill.
8) Leaves more of the tooth intact.
9) Leaves the treated areaof the tooth relatively dry, making sealants and fillings bond better.
10) Reduces the risk of micro- fracturing , a problem sometimes caused by drilling.
11) Reduces failure rate of bonded orthodontic brackets.
12) Increases retention of composite placed on unprepared enamel.

The whole procedure is simple and quick, allowing the dentist to treat multiple sites in one visit, often without anaesthesia.

Advantages Of Air Abrasion;

1) Non-traumatic treatment
2) biocompatibility
3) no chipping
4) no micro fracturing
5) decreased thermal build up
6) Micro smooth margins
7) Less invasive procedure that preserves more natural tooth structure than conventional instrumentation.
8) Greatest strength and longevity because of lesser preparation.
9) No anaesthesia.
10) Less Discomfort during preparation

Contraindications Of Air Abrasion:

1) Asthma patients
2) Severe dust allergy
3) Chronic pulmonary disease.
4) Recent extraction
5) Open wounds in oral cavity
6) Subgingival caries removal.Safety issues[27],[28].

Limitations

Though air abrasives can be used in a large number of clinical situation there certainly are some limitations to their use such as:-

1) Air abrasion is not an efficient means of removing large amalgam restoration especially, and there is concern for the levels of mercury released when amalgam is abraded. Air abrasion of amalgam for 1 min. releases mercury vapour four times in excess of OSHA standard[29].
2) Not applicable to all aspects of dentistry.
3) Lack of tactile sensation when using the air abrasion hand-piece,because the nozzle of air abrasion instrument does not come in contact with the tooth.
4) Non- contact based modality, leading to significant risk of cavity over preparation and inadequate carious dentin removal. Depth of penetration during cavity preparation cannot be controlled.
5) Chances of spread of aluminum oxide around the dental operatory.
6) Danger of air embolism and emphysema.
7) Impaired indirect view because abrasive particles collect on mirror rapidly blocking the viewing surfaces.
8) Damage to dental mirrors, optical devices like magnifytng loupes, intraoral camera lenses or photographic equipment as rebond particles could damages to the lenses.
9) Non efficient in removing large amalgam restoration.
10) Non- effective in removing gross caries because it does not cut substance that softer or resilient.
11) Risk of damage or laceration to soft tissues[30],[31],[32],[33].

Safety Measures

There is a risk of inhalation of alumina particles during usage of air abrasion unit. The particles inhaled are more than 10µm in size and cannot enter the alveoli. To reduce respiratory exposure, use surgical face masks &dry vacuum systems. High speed suction and an external vacuum system are necessary to capture the powder that escape into the air and to enhance practitioner vision and patient comfort. Use rubber dams, protective eye glass and dead soft metal matrix to protect adjacent tooth structure. Use disposable mouth mirrors. Rinsing instead of rubbing the optical surfaces helps to prevent scratches. Bioactive glass can replace alumina in air abrasion system. But bioactive glass is brittle and fracture when come in contact with hard tooth structure.

Bioactive Glasses And Air Abrasion

Many dental practitioners are concerned about the toxicity of alumina particles which can be inhaled during the procedure. Bioactive glasses can replace alumina in air abrasion system. But bioactive glasses are brittle and they fracture after coming in contact with hard dentin surface. The hardness of bioactive glasses is less than alumina but they can cause remineralization of the surface unlike alumina. Therefore, bioactive glasses of different composition and hardness should be produced to test their cutting efficiency.

Conclusions

The resurgence of air abrasive technology with new restorative materials has given a new dimension to "Minimally invasive dentistry". Minimally invasive dentistry is now an essential part of dental procedures. Air abrasion is now used by many dental practitioners in USA and it is still gaining popularity in Europe

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