Cleaning suction lines - a practical approach

By Emeritus Professor Laurence J. Walsh AO

A dental suction system is designed to remove saliva, blood, remnants of dental hard tissue and dental materials and debris generated during clinical procedures from the mouth. By removing these, dental suction makes clinical procedures faster as well as safer. This is true whether one is working in a regular clinic with a dental chair or from a mobile dental delivery system. This article outlines the science and practical considerations that support the proper treatment of dental suction lines, regardless of the nature of the dental service.

Effective suction for reducing aerosols

Effective high volume evacuation is recognised as a key component of strategies that mitigate the risk of infection to dental staff, including from aerosol-generating procedures performed on dental patients with upper respiratory tract infections. High-volume evacuation (HVE) using wide bore intraoral suction tips has been shown to be highly effective in reducing salivary contamination of the surrounding environment.

There is an extensive literature that supports the view that with correct placement of HVE, aerosols and spatter should be reduced by 90% or more.[1-14] This makes maintaining the suction system a critical component of safe working practices in everyday dental practice.

HVE also reduces contamination in the areas immediately beyond the dental chair when open plan clinic designs are used, keeping the majority of contamination within 1.5 m of the patient's head. The reason for this is that suction removes smaller lighter droplets (aerosol) easily and it is these that likely cause more distant contamination. These considerations explain why dental suction with a wide bore aspiration tip fitted to HVE should be an essential component of dental treatment, especially for dental chairs in an open plan clinic layout.[15]

Suction line configurations

Current definitions for dental suction are as follows: low volume (40 L/min air), medium volume (159 L/min air) and high volume (250 L/min air).[16] High volume suction hoses usually are equipped with special connectors and adapters into which wide bore (8 or 10 mm diameter) suction tips are fitted prior to each patient treatment. The tip will move ~4 litres of air per second, or more. HVE connectors often contain valves to regulate suction strength. They may also have metal or plastic adaptors to join various tips to the suction hose. In contrast, single patient-use saliva ejector tips (3-4 mm in diameter) are fitted to the low volume suction line. This line moves only ~1 litre of air per second or less.

HVE is essential during all aerosol-generating procedures, including those using handpieces, ultrasonic and sonic devices, air polishing devices and hard tissue lasers.[8,13,17] Different designs of suction tips and attachments can enhance the protective action of suction by better removal of aerosols during caries removal with a high-speed handpiece and other dental aerosol-generating procedures. As well, correct placement of the tip of the high-volume evacuator, facing the aerosol-generating procedure side, will significantly reduce the level of ultrafine particles produced during restorative dentistry.[18,19]

The Isolite® illuminated isolation system attaches to the HVE connector and is designed for use by clinicians such as dental hygienists who are working without a dental assistant.

The Isolite is designed to provide simultaneous suction to both the maxillary and mandibular quadrants on one side, as well as illumination. Its performance for achieving aerosol reduction has been challenged, with a clinical study of its use during ultrasonic scaling showing no benefit over a saliva ejector. Neither the Isolite device nor the saliva ejector can effectively reduce aerosols and spatter during ultrasonic scaling.[20]

Saliva ejectors and low volume evacuation

Several studies from the 1990s have shown that, under certain conditions, liquid from the saliva ejector's low volume evacuation suction line can enter a patient's mouth during use. This can occur in a transient way accidentally when there is occlusion of the mouthpiece opening by the oral mucosa, or when there are oscillations in suction produced by operating other suction equipment. It can also occur deliberately when patients apply greater suction force than what is provided by the saliva ejector, as they suck or close their lips around the saliva ejector. In this case, the negative pressure in the patient's mouth is greater than that in the saliva ejector, causing backflow of previously aspirated fluids. Gravity assists such backflow when the LVE suction tubing holding the tip is positioned above the patient's mouth.[21,22]

Microbiological studies of saliva ejector low velocity suction lines reveal that these are coated with microbial biofilms. The dense deposits of metabolically active Gram-positive cocci and Gram-negative bacilli are embedded in an extensive polysaccharide matrix.[23]

Saliva ejector lines are just as contaminated as HVE suction lines and a wide variety of microorganisms are present. Hence, retraction of oral fluids and biofilm-derived microorganisms from contaminated suction hoses could potentially be a source of cross-contamination and cross-infection. When oral fluids from a previous patient are taken into the mouth, there is also the risk of transmission of viruses that may be present in saliva, including Epstein Barr virus, cytomegalovirus, Herpes Simplex and other herpes group viruses.[24]

Removing hard deposits from suction lines

Everyday maintenance of suction lines is essential. These lines are prone to the accumulation of mineral deposits as well as microbial biofilms. Formation of mineral deposits can be promoted by materials suctioned from the oral cavity, like remnants of fluoride gels, prophy paste, abrasive powders and cements, because these contain anions (such as carbonates, phosphates, sulphates and hydroxides) that can form insoluble precipitates with metal cations (such as calcium, magnesium and aluminium). Mineral formation will be faster when the water exiting from the dental unit is hard, as hard water has higher levels of such anions and cations and a higher propensity to form mineral scale deposits. As hard deposits build up over time in dental suction lines, they reduce the effective diameter of the suction lines. They also provide a rough surface onto which microbial growth can occur.

To address hard deposits, periodic cleaning of suction lines using a product than can dissolve such deposits is needed. While mineral deposits could in theory be dissolved away using strong acids (such as HCl), these will cause corrosion of metal components in the suction system (such as butterfly valves and solenoids), as well as numerous other bystander reactions. Working with concentrated HCl would also pose significant work health and safety issues for staff because of its volatile nature (generating highly irritant fumes) and its ability to cause soft tissue injuries.

As a result, suction system cleaners use mineral chelators, instead of strong acids, to dissolve mineral scale. These pose much less issues for OH&S and are less likely to cause corrosion of metal components (like valves) than strong acids. As they bind tightly to divalent and trivalent metal ions, they have a water softening action, which suppresses further formation of insoluble precipitates.

Phosphonates are stable under the low pH conditions that are best for dissolving away mineral deposits. Phosphonates are used widely in water treatment processes including desalination and reverse osmosis so their chemistry is well known. Phosphonates are the major active ingredient used in Eurosept Xtra Evac Cleaner®

Weekly Concentrate, which is designed for removing hard deposits from suction lines. This product has a low pH (<2) which assists in breaking down mineral deposits and amphoteric surfactants to increase the contact of the solution with the walls of the tubing.

Removing soft deposits from suction lines

Microbial biofilms form in dental suction lines for several reasons. First, the suction hoses are repeatedly contaminated with oral microorganisms. These have multiple origins, including from coolants and irrigant solutions, tap water, dental unit waterlines and the patient's dental plaque, saliva and blood.[25-27]

Second, the suction lines are often wet. Flowing water provides a shear force along the walls of the lines. This provides an environment that is highly conducive to the growth and proliferation of microorganisms in a dense adherent biofilm. Field studies show that heavy microbial contamination of the dental suction lines extends from the dental chair to the suction unit and thereafter from the suction unit drain lines.[28]

Third, a generous supply of proteins and other nutrients from saliva and blood ensures the rapid growth of many types of microorganisms as well as numerous species within one type. As an indicator of high levels of blood exposure, direct evidence for high levels of blood being retained on the inner surface of suction tips after periodontal debridement has been provided using the Kastle-Meyer reagent test, in which a colour change to purple indicates the presence of fresh or dried blood.[29]

Typical organisms that have been isolated from dental suction systems are listed in Table 1. Levels of Gram negative bacteria in dental suction line biofilms can exceed 500,000 CFU per square cm. Similar issues have been found in medical suction systems used in hospitals, which have caused outbreaks of infection involving different opportunistic Gram-negative bacteria.[30,31]

An important pathogen found at high levels in dental suction lines is the Gram negative bacterium *Pseudomonas aeruginosa,* which is able to outcompete many other bacteria. It grows well in wet regions and on PVC and medical tubing.[32-35] This is particularly relevant during the COVID-19 pandemic, as forced shutdowns may result in dental chairs remaining unused or under-used for extended periods of time. *P. aeruginosa* and other pathogens are able to remain viable during periods when nutrient levels are low. The presence of Pseudomonads explains why suction line biofilms can be coloured green, yellow or brown.

Table 1. Microorganisms isolated from biofilms in suction lines

Gram negative bacteria

- *Pseudomonads* including *P. aeruginosa, P. fluorescens* and *P. putida*
- *Alcaligenes xylosoxidans*
- *Aeromonas salmonicida*
- *Acidovorax temperans*
- *Burkholderia cepacian*
- *Comamonas acidovorans*
- *Novosphingobium subarctica*
- *Serratia marcescens*
- *Sphingomonas spp.* including *S. aerolata, S. paucimobilis* and *S. trueperi*
- *Stenotrophomonas maltophilia*

Gram positive bacteria

- *Bacillus spp.*
- *Streptococcus spp.* including *S. pneumoniae, S. salivarius* and *S. mitis*
- *Staphylococcus spp.* including *S. aureus, S. epidermidis S. haemolyticus* and *S. warneri*

Fungi

- *Acremonium*
- *Rhotodotorula*
- *Cladosporium*
- *Fusarium*
- *Aurobasidum pullulans*

Data collated from multiple studies undertaken at Trinity College, Dublin, Ireland by M.A. Boyle and M.J. O'Donnell

Suction line odours

Breakdown of proteins from saliva and blood that contain amino acids with sulphur atoms results in the release of volatile sulphur compounds (VSCs), such as hydrogen sulphide (H_2S), methyl mercaptan (CH_3SH) and dimethyl sulphide [$(CH_3)_2S$]. These have a characteristic unpleasant odour.[36,37]

Such odours will provide an unsatisfactory environment for both patients and staff when they accumulate during periods when the dental clinic airconditioning is not operated or if the dental operatory is poorly ventilated.[38]

More of such odours will be noticed in the dental operatory when biofilm levels in the lumen (i.e. on the internal walls) of the suction tubing are high. When this problem is found, the likely causal factors (Table 2) should be explored. Using the correct product at sufficient frequency (at least once per day at the end of the day) will minimise biofilm formation. When odours are present when the suction is off, indicating that biofilm levels are high, more frequent treatment (e.g. twice daily until the problem resolves) would be appropriate.

It is also important to note the problem of leakage from suction system hoses at their sites of attachment to the dental chair, caused by gradual loosening during use. One study of variations in microbial flora in dental suction lines reported the presence of some *P. aeruginosa* strains (such as serotype O:10, SpeI fingerprint group II) that seemed particularly well adapted to survive in dental suction systems and which may be particularly resistant to disinfection. In the situation reported, the suction lines had been disinfected after each clinical session (i.e. twice daily, Monday–Friday) with a phenolic disinfectant (PuliJet® from Cattani) in a process that took approximately 1 minute. This regular disinfection with Pulijet appeared to be ineffective at controlling bacterial contamination in the suction system. The very short contact time that the disinfectant had with the inside surfaces of the suction system (i.e. approximately 1 min) was also thought to be a contributory factor.[24]

Other studies also reinforce the point that dental suction systems become heavily contaminated during use and that conventional disinfection protocols may not be entirely effective at controlling this issue. Prolonged biofilm growth can lead to issues with the suction handpiece valves that are used to regulate suction strength either leaking or becoming stuck in one position. Leaks occur because extensive microbial biofilms on O-rings have caused these seals to perish. A stuck valve can be due to congealed blood, as well as corrosion of metal components.[39]

Table 2. Factors that promote growth of biofilms in suction lines

Irregular/insufficient flushing with an appropriate antimicrobial solution

- Frequency is too low
- Volume of product used is too low
- Exposure time for the product is too short
- Product concentration is too low (incorrect dilution ratio, product expired, incorrect solvent used)
- Tap water used for product dilution is hard

Frequent surgical and periodontal debridement procedures where blood is generated, with insufficient flushing using water or saline at the end of the procedure

Product compositions for disinfection

Principles for microbial control of biofilms in suction lines have parallels to those used for dental unit waterlines, particularly flushing and periodic aggressive chemical treatments to disrupt biofilms.[40-42] An important distinction is that the nutrient environment is rich in the suction lines, resulting in more vigorous growth of microorganisms. The microbial diversity is greater, with bacteria, fungi and amoeba being present. This is why active ingredients with broad spectrum disinfecting actions are needed for treating dental suction lines and why dental suction lines must be disinfected regularly.[43,44]

It is not practical to detach suction hoses (for thermal disinfection) either after each patient or on a daily basis, hence aspiration of chemical disinfectants on a regular basis is needed. Most dental chair manufacturers suggest this be done at least once daily, at the end of the working day. Field studies reveal that compliance with this recommended frequency of suction system disinfection varies widely.[45]

Products used for breaking down the matrix of biofilms and killing microorganisms will typically contain low foaming surfactants, as well as disinfectants and fragrances, with the latter providing a deodorising action. Using enzymes at neutral pH is a highly effective strategy for breaking down complex biofilms. Eurosept Xtra Evac Cleaner® Daily is an example of an enzymatic cleaning concentrate, designed for daily cleaning and care of dental suction systems. This product is pH neutral and contains non-ionic low-foaming surfactants. These ensure maximal penetration of the enzymes into soft deposits of organic matter such as residues of blood, saliva and biofilms.

Chemical compatibility with suction system components and amalgam separators is another important consideration. Use of strong oxidants could lead to powdery corrosion of aluminium components such as manually operated suction butterfly control valves and suction tip connectors following prolonged use. These deposits of aluminium oxide can impair the action of the control valves and impair proper intake of air. This will not occur if the butterfly control valves and suction tip connectors are made from high-quality, acid-resistant steel as that will resist corrosion by strong oxidants such as hydrogen peroxide.[46]

A variety of factors can contribute to failure of suction line disinfection in the long term, including human errors (not following use protocols; incorrect product selection; incorrect dilution), as well as corrosion and deterioration of the suction lines and suction equipment.

Disinfectants used in suction cleaners designed for daily use will need a broad antimicrobial spectrum. When considering possible candidates, chemical inactivation, optimal pH, interactions with proteins and ecological effects in water systems are parameters to consider,

as well as the likelihood of corrosion. Keeping close to a neutral pH is desirable for material compatibility.

Typically, suction cleaners are designed for both being used in the suction system and also being poured into the spittoon, at the same concentration. Follow the manufacturer's instructions and check whether the product is low foaming before attempting to treat a spittoon.

Correct product handling and usage

Suction cleaners can combine the two functions of reducing biofilm and dealing with mineralised deposits, and various manufacturers have developed protocols around optimising both functions. Some have taken the approach of a frequent-use product where microbial control is paramount and a periodic use product (e.g. twice weekly) formulated to dissolve mineral deposits.

For efficient transport, products may be shipped as concentrates which are then diluted, typically with ordinary tap water. The final mixture is then run through the suction system and/or poured down the spittoon.

Conclusions

Dental suction is essential for safe dental practice and HVE is a critical component of infection control work practices that remove aerosols and reduce their spread. The COVID-19 pandemic has made dental practices more aware of the importance of proper HVE. For proper performance, dental suction lines need regular attention to remove both hard deposits and microbial biofilms. The products used must remove these deposits while not causing corrosion or other forms of deterioration. Well designed products used in the right way will also ensure that problems such as the generation of odours do not occur when the dental chair is not in use.

About the author

Emeritus Professor Laurence J. Walsh AO is a specialist in special needs dentistry who is based in Brisbane, where he served for 36 years on the academic staff of the University of Queensland School of Dentistry, including 21 years as Professor of Dental Science and 10 years as the Head of School. Since retiring in December 2020, Laurie has remained active in hands-on bench research work, as well as in supervising over 15 research students at UQ who work in advanced technologies and biomaterials and in clinical microbiology. Laurie has served as Chief Examiner in Microbiology for the RACDS for 21 years and as the Editor of the ADA Infection Control Guidelines for 12 years. His published research work includes over 330 journal papers, with a citation count of over 15,400 citations in the literature. Laurie holds patents in 7 families of dental technologies. He is currently ranked in the top 0.25% of world scientists. Laurie was made an Officer of the Order of Australia in January 2018 and a life member of ADAQ in 2020 in recognition of his contributions to dentistry.

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