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ULTRASONIC SCALING: UNFORE SEEN RISKS.

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ABSTRACT:. **Background and overview:**Scaling and root planing is one the basic clinical procedures performed as a part of the preventive periodontics routinely. This nonsurgical procedure can be performed using hand instruments or ultrasonic instruments. Since a very long time ultrasonic scaling was assumed to have no adverse effects but of late reports have contradicted this assumption.
Clinical implications: Exposure to any hazards from ultrasonic scaling is most significant to the patient, clinician and clinical aides. As they are often repeated procedures for the patient and occur for prolonged durations on the dental team careful attention has to be paid to counteract them. The effects may be thermal , pulpal, auditory, tooth substance loss and even aerosol contamination.
Conclusion: Though there is a dearth of documented damage from ultrasonic scaling the matter needs probing in. Any patient who sits on a dental chair is normally assured of absolute safety which has to be ensured at any cost.

KEYWORDS: Scaling, Ultrasonics,Dental Chair,Root Planning, Aerosol Contamination.

INTRODUCTION

The periodic mechanical removal of microbial biofilms (bacterial plaque) is essential for controlling inflammatory periodontal diseases because disease causing bacteria can repopulate pockets within weeks following active therapy.[1]

The instruments of choice are either hand instruments, ultrasonic or air driven scalers.[2] Manual instrumentation was the only method available for safe removal of supragingival and subgingival calculus until the ultrasonic scaling device was introduced in the 1955.The effect of ultrasonic energy for dental instrumentation has a profound effect on the profession and public. The two categories of mechanized instruments are ultrasonic and sonic handpieces.[3]

The ultrasonic scaler may result in potential hazards to both the patient undergoing treatment and to the clinical operator of the equipment. Some of the commonly encountered hazards are elaborated on.

Airborne disease transmission
Dental aerosol and splatter

Aerosol and splatter are a concern in dentistry because of their potential effects on the health of the immune-compromised patients and on dental personnel. There is also regulations by the Occupational Safety and Health Administration, or the OSHA about aerosol contamination abolition as a part of standards for indoor air quality. One of the reports indicate that the ultrasonic scaler is the greatest producer of contaminated aerosol and splatter.[4]

Micik and colleagues defined dental aerosols as being particles smaller than 50 micron meters with any particles larger than 50µm being described as splatter. [5] They stated that these particles behaved in a ballistic manner. It means that these particles or droplets are ejected forcibly from the operating site and they arch in a trajectory similar to that of a bullet until they contact a surface or fall to the floor.[4] Infectious aerosols are capable of causing illness and are composed of two types: dust borne or droplet nuclei. Dust-borne aerosols are large in diameter. They are easily removed from the air by sedimentation or filtration and are less likely to carry microbes that induce illness .These specific aerosols are not seen as a direct threat to infection control. Droplet nuclei, however, are smaller in size and settle out of the air slowly. These can be easily spread throughout the dental operatory by air currents, which can lead to contamination of the atmosphere. Droplet nuclei particles can remain in the environment for long periods of time, which make them a greater threat to the patient and health care provider.[6]

Both large and small aerosol particles may contain blood elements with attached viral particles , such as Human immune-defeciency virus and Hepatitis B virus. The material produced by ultrasonic scaler is composed of both large and small particles, and this aerosol and splatter have been shown to routinely contain bacteria and blood. [7]

Some diseases known to be spread via an airborne route are listed below.[4]

1. Pneumonic Plague
2. Tuberculosis
3. Influenza -
4. Legionnaires' Disease
5. Severe Acute Respiratory Syndrome

Sources of airborne contamination during dental treatment **:** There are at least three potential sources of airborne contamination during dental treatment: Dental instrumentation, Saliva along with respiratory sources and the operative site. Contamination from dental instrumentation is the result of organisms on instruments and in DUWLs.[4]

Saliva and respiratory sources of contamination

The oral environment is inherently wet with saliva that is grossly contaminated with bacteria and viruses. Patients with undiagnosed active, infectious TB pose a risk for the dental team and other patients. The saliva and nasopharyngeal secretions also may contain other pathogenic organisms like influenza viruses, herpes viruses, pathogenic streptococci and staphylococci and the SARS virus. Checchi et al. reported that about 150 billion microorganisms can be found in 1g of fluid taken from the gingival crevice of a patient who has poor oral hygiene and that about 6 billion are present in 1 m L of saliva.[4]

Contamination from operative site **:**Dental handpieces, ultrasonic scalers, air polishers and air abrasion units produce the most visible aerosols. Each of these instruments removes material from the operative site that becomes aerosolized by the action of the rotary instrument, ultrasonic vibrations or the combined action of water sprays and compressed air. [4]

Composition of dental aerosols : Qualitative and quantitative analysis of the makeup of dental aerosols would be extremely difficult and the composition of aerosols probably various with each patient and operative site. However, it is reasonable to suppose that components of saliva, nasopharyngeal secretions, plaque, blood, tooth components and any material used in the dental procedure, such as abrasives for air polishing and air abrasion, all are present in dental aerosols.[4]

Aerosol production: As the flow of cooling water passes over the oscillating probe tip, surface waves will be formed along the air/water interface. When the displacement amplitude of the probe is sufficiently high this water will be ejected into the air as droplets to form an aerosol.[4]

An in vivo study by Barnes et al was carried out to determine if blood is present in the aerosols produced by subgingival ultrasonic scaling. In this study there is no difference in positive results for blood in the ultrasonic aerosols despite the large difference in coolant volume and High Volume Evacuator pressures measured at the two offices. It is obvious that ultrasonic scalers produce aerosols, and this study confirms that these aerosols may routinely contain blood from gingival sulcus and possibly, whatever pathogenic agent that may be present in the blood.[8] The risk to subsequent patient in the treatment room will be almost entirely eliminated if there is a period of between 10 and 30 minutes between scaling and the entry of next patient into the room. [9]

Vibrational hazards: It is well recognized that the large amplitudes produced by pneumatic drills will cause “white finger” .This is a disruption in the blood flow to the fingers, caused by the vibration that is passed from the drill through to the hand. The vibration amplitude associated with dental scalers is small but may still have the potential to produce this phenomenon.[10]

A study was undertaken with a group of 120 subjects. It consisted of 60 dentists and hygienists exposed to vibrations, from high-speed hand pieces and ultrasonic scalers and a control group of 60 dental assistants and medical nurses.[11]They were assessed for manual performance, tactility, strength, etc In this study, it was found that the vibrations could produce a reduction in strength and tactile sensitivity and performance due to the disruption of blood and nerve supplies to the fingers.

Thermal hazards; If the ultrasonic scaler is perfectly coupled at the probe/enamel interface then about 37% of ultrasonic energy would leave the metal and enter the tooth(Walmsley et al). [12] However this will not occur in practice because

1. The dimentions of the probe tip (approximately 10 mm^2) are much smaller than the wavelength of sound at these frequencies (approximately 23 cm at 25 kilo Hertz).
2. There is usually a thin layer of water imposed between the probe and the tooth.
3. There will be a difference in transmission if the longitudinally oscillating tip is applied perpendicular or parallel to the tooth.

If heavy contact pressures are used then coupling will be improved increasing the amount of ultrasound entering the tooth. One of the major sources of damage to the tooth is the result of frictional heating between the probe and the enamel especially if there is inadequate or no water cooling. However the presence of water may act as a matching layer allowing uniform ultrasound energy to enter the tooth. This energy will be uniformly absorbed resulting in heating of the tooth, although any heat produced would be expected to be removed largely by blood flow together with the transmission of ultrasound into the surrounding bone. [12]

A study by (Walmsley et al 1986) has shown that despite the small area of contact and the large acoustic mismatch between the steel scaling tip and the tooth ,some vibrational energy is transmitted into the tooth. Absorption of acoustic energy alone can result in an elevation of tooth temperature *in vitro* of upto 2 degree C. Further research is required however to determine whether sufficient vibrational transmission also occurs *in vivo* to a level which will produce a deleterious biological effects on the dental pulp.[12]

Thrombogenic hazards: During dental treatment the oscillating tip of ultrasonic scaler will be in contact with tooth.[13]It may be possible that the tooth acts as a waveguide conducting the vibrational energy from the scaler towards the apex of the root .If sufficient energy reaches the root then it could pose a thrombogenic hazard to the blood vessels passing through the apical foramen into the pulp. This may lead to a potential loss of tooth vitality.

An in vitro investigation was undertaken to determine whether the thrombogenic hazard may occur in mammalian blood vessels exposed to clinical levels of dental ultrasound. During routine use only the crown of the tooth will be contacted by ultrasonic scaler. However if sufficient acoustic energy were to enter the tooth during ultrasonic scaling then some of it may be transmitted toward the apex resulting in thrombus formation with potential blood vessel occlusion of the afferent pulp vessels .The results of the above study show that acoustic microstreaming fields may be generated on the surface of the tooth root around the entrance to the pulp canal during ultrasonic scaling produced *in situ.* [13]

Thus ultrasound transmission into the tooth may result in potential damage to the structures such as blood vessels both within and around the teeth.

Cavitational hazards: If trauma occurs to a blood vessel, then the function of platelets is to adhere to each other or to materials such as collagen while releasing potent chemicals to initiate and accelerate the blood coagulation system. Blood platelets are sensitive to shear stresses and such forces are produced by the occurrence of acoustic microstreaming around an ultrasonically oscillating wire.[10]

Ultrasonic scalers produce acoustic micro streaming fields around the scaling tip. The shear forces produced are more than powerful enough to damage platelets. Ultrasonic cavitation occurring within the cooling may also produce small petechial lesions within the blood vessels of the immediate gingiva and small particles of dislodged calculus and associated bacteria may be driven into these tissues by the shockwaves of cavitation resulting in areas of necrosis which may then become infected .It is not known, however whether this will result in an increased incidence of gingival infection.[12]

In summary, the cavitational activity caused by the ultrasonic scaler can affect the blood flow within the tooth.Further work is required to look into the significance of possible changes to the periodontal tissues caused by cavitation.[10]

Interruption of electronic devices

The main electromagnetic device of vital importance is the cardiac pacemaker.

Cardiac pacemakers

The cardiac pacemaker is a tissue implanted electrical transmitter designed to regulate the rhythm of the heart. Two types used are competitive (fixed rate type) and noncompetitive (demand type), the former discharging at a fixed rate while the latter only discharges if the rate becomes irregular. The noncompetitive/demand pacemaker is exclusively used at present (Adams et al 1982). [14]

The electromagnetic field produced by the magnetostrictive ultrasonic scalers during operation may interfere with the pacemaker discharge rate, resulting in a serious life threatening hazard to the patient (Griffith, 1978).[15]

It has been suggested that any effects which have been observed may be the result of a noncompetitive type of pacemaker switching over to a fixed mode during the period of interference (Mokrzycki,1982).[16]

No reports of interference caused by piezoelectric scaler have been reported.[14]There is clearly a conflict between the results obtained by the different workers however, and caution is recommended when treating the cardiac pacemaker patient with a magnetostrictive ultrasonic descaler.[12]

Auditory hazards: Lesions of hearing apparatus can be described as chronic or acute. Acute acoustic trauma is caused by a high intensity noise stimulus such as an explosion or gunfire. The onset is painful and may or may not be reversible.Chronic acoustic trauma is caused by prolonged exposure to lower intensity sound irritant. The onset of lesion is not associated with pain. The damage is irreversible because cochlear hair cells cannot regenerate. Although a certain amount of gradual hearing loss is considered normal as a part of ageing (presbycusis), prolonged exposure to excessive noise can add to the hearing loss.[17]

Kilpatrick proposed a number of sounds in the dental office that may be hazardous to dentists hearing: [18]

1. High-speed turbine
2. High-volume aspirator
3. Ultrasonic scaler
4. Mixing devices for stone,amalgam,etc
5. Music playing loudly and continuously

Ultrasonic scalers may be a potential hazard to the auditory system of both clinicians and patients. Damage to operator hearing is possible through airborne sub-harmonics of the ultrasonic scaler. For the patient, damage can occur through the transmission of ultrasound through tooth contact to the inner ear via the bones of the skull. This latter hazard is a possibility during scaling of the molar teeth. [10]

Degree of risk to the individual dentists depends on several factors [17]

1. Intensity of noise.
2. Frequency spectrum of noise
3. Duration of exposure each day.
4. Distance from the source.
5. Individuals age, physical condition (existing hearing condition) and susceptibility.
6. Type of preparation.
7. The intensity of noise emitted from handpieces differs from manufacturer to manufacturer.
8. Position of the dentists head to the handpieces.
9. Previous exposure to damaging noise resulting in permanent injury to hearing.
10. Materials in the room like smooth cement walls and floors reflect noise almost completely, whereas draperies absorb noise considerably.

In United Kingdom, The Noise at Work Regulations state that a maximum exposure of *85 decibels* is permissible daily during an 8-hour working period. [19]

A study was undertaken to measure the noise levels made by different dental handpieces and equipment in dental practices and laboratories .Noise levels were measured in four dental practices and three dental laboratories .In the dental clinics almost all of the noise produced by the dental instruments did not exceed the maximum permissible level of 85dB.The only instrument that seemed to emit noise that was higher than 85 decibels was the ultrasonic scaler in one of the dental clinics. [17]

Moller et al reported temporary threshold shifts in hearing in eight out of 20 subjects following a 5-minute ultrasonic scaling procedure. Unilateral changes of 10-20 decibels (dB) in the frequency range of 3-10 kHZ were demonstrated in these patients, three of whom had bilateral tinnitus. Both tinnitus and temporary threshold shifts (TTS) are commonly accepted as early predictors of noise-induced hearing loss (NIHL).It may therefore be possible that sufficient high displacement amplitude

energy is transmitted to the inner ear by bone conduction to damage the sensory structures, especially when scaling the upper premolar and molar teeth. The liberal use of dental ultrasonic instruments may therefore pose a potential hazard to the hearing of the patient. [20] In summary ultrasonic scaler may produce temporary hearing shifts in the patient and clinician, although there is no evidence of permanent damage .Work is needed to identify if a potential hazard to hearing exists for the patient and if this is an increased problem for patients who receive regular ultrasonic scaling. [10]

Root surface removal by ultrasonics

Zappa et al investigated on the loss of root substance in scaling with various instruments. Measurement of tooth substance loss was carried out with a specially constructed measuring device at 360 sites on 90 mandibular incisors following 12 working strokes with a clinically appropriate force of application. Only a thin layer of root substance 11.6 microns was removed by ultrasonic scaler, compared to the much greater losses sustained with the airscalers 93.5microns,the curette 108.9microns and diamond bur 118.7microns.[21]

Evidence shows that ultrasonic and sonic scalers are effective in plaque and calculus removal however , surface alterations including scratches, gouges, and nicks increase exponentially as the ultrasonic power is increased from medium to high. Studies also reveal that as instrument contact time, tip to tooth angle, and instrument pressure is increased, the likelihood of root surface damage is also increased. In addition the angulation and design of the instrument tip, sharpness of the working edge, the length of time the instrument is in contact with the root and the cumulative effect of number of strokes have an impact on the degree of root damage. [22] The magnitude of the root substance removed suggests that repeated scaling and root planing could eventually lead to approximation of the pulp chamber or to pulp exposure.

Dental unit waterline contamination

Portable water is defined as less than 500 colony forming units per millimeter (CFU/ml).Water recovered from dental units connected to municipal water supplies may contain millions of bacterial colony forming units per millimeter. Biofilms are microbial accumulation that adhere to the interior surfaces of the waterline tubing. These biofilms have been shown to be a primary source of contaminated water delivered by dental units. Dental tubing presents a favourable environment for bacterial colonization because fluid flow is practically stagnant near the tubing walls. Parts of the biofilm frequently disengage from the tubing wall and can be carried into the patients mouth .[23]

Patients at risk of infection linked to dental treatment include the elderly, individuals with chronic medical conditions, diabetics, smokers, alcoholics, immunosuppressed (i.e. organ transplant or cancer patients) and HIV –positive individuals. Patients and clinicians temporarily compromised by infections and stresses may also be at risk for infection.[3]

Range of microbial flora identified in dental unit waterline samples by use of morphological and biochemical characteristics.

Pseudomonal aeruginosa	Achromobacter xyloxidans
Pseudomonas cepacia	Klebsiella pneumoniae
Pseudomonas fluorescens	Serratia marcescens
Pseudomonas vesicularis	Nocardia spp.
Pseudomonas posimobilis	Streptococcus spp
Pseudomonas pickettii	Micrococcus luteus
Pseudomonas acidovorans	Flavobacterium indilogenes
Pseudomonas testosteroni	Staphylococcus saprophyticus
Pseudomonas stutzeri	Staphylococcus capitus
Xanthomonas maltophilia	Staphylococcus warneri
Pasteurella haemolytica	Staphylococcus spp.
Pasteurella spp. [24]	Legionella spp
	Alcaligenes denitrificans
	Bacillus spp
	CDC group IV c-2
	Acinetobacter spp
	Ochromobacterium anthropi

A survey undertaken by Williams et al in the Western United states reported on the scope of the contamination problem and the profile of the microbial populations involved.[24] Dental unit waterlines (DUWL) samples were collected from 116 three-way syringe lines, 54 high-speed handpieces and 12 scaler lines from about 150 operatories at 54 sites in Washington, Oregon and California. Samples from 12 scalers showed similar pattern of severe microbial contamination (19,800 cfu/mL).Sections of functioning dental unit waterlines showed complete biofilm layers lining the inner surface. The study indicates that contemporary dental units are highly likely to be delivering water heavily contaminated with the wide variety of microbial organisms.

A paper by Caroline et al examined why dental unit water contamination occurs, assessed the relative risk of contaminated water and aerosols to dental surgery staff and patients. Dental units are equipped with micropore (approximately 1mm in diameter) flexible tubing which has high ratio of lumen surface area to water volume. Bacteria adhere more readily to hydrophobic polymeric plastic tubing of the type ultilized in dental equipment (i.e. polyvinyl chloride, polyurethane) than to those composed of glass or steel. Organisms in the DUW biofilm are predominantly derived from the incoming mains water. Once a new DUW system is connected to mains water supply, even when it is not used for patient treatment, a biofilm will form within 8 hours. The biofilm will develop to reach a climax community of microcolonies embedded in a protective extracellular amorphous matrix by 6 days. Characteristically the biofilm bacteria exhibit greater resistance to surfactants biocides and antibiotics than organisms floating freely in fluids.[25]

Detachment of surface microorganisms from the biofilms in DUWL allows them to exit in the coolant of high-speed dental handpieces, in the flow of air-water syringes (AWS), and from ancillary equipment such as ultrasonic scalers attached to the dental units. These bacteria can then be flushed into the mouths of dental patients and become airborne as aerosols and droplets of splatter.[26]

Summary

Ultrasonic instrumentation has become indispensible for routine and specialized periodontal treatment procedures over the years. Any mechanized device usage is fraught with certain inherent disadvantages. Most of the above mentioned risks can be circumvented with appropriate precautions. A conscientious clinician would always weigh the benefits to risks and deliver the optimal treatment procedure that is available to his/her patients.

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