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OCCUPATIONAL ULTRASONIC NOISE EXPOSURE AMONG DENTISTS- AN OVERVIEW

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ABSTRACT

Dental professionals are exposed to various sound levels in the operatory which can cause potential damage to hearing ability. This paper aims to highlight the auditory and nonauditory hazards of noise exposure in dental operatory. Various tests are being advised which assess the auditory functions in dental professionals. Appropriate measures has to be followed by the dentists as well as in the operatory area to minimise risk of unwanted noise exposure and its consequences.

KEYWORDS: Occupational ultrasonic noise, Hearing loss, Auditory functions evaluation.

INTRODUCTION

As dental professionals, we are exposed to noise of various sound levels while operating in dental clinics and laboratories.[1] Dentists work continuously in a noisy environment for at least 8 hours per day and around 8% of their 24-h noise exposure is from the dental practice.

Among the usually used dental equipment producing noise which is appreciable, ultrasonic scalers are one of the most frequently used instruments that emit noise of terribly high frequency and are related to hearing impairment risk in approximately 51% of dental professionals. It produces sound within the vary of 70–120 dB at a frequency of 25,000 hertz.[2] Noise can induce various health related issues as masking of unwanted sounds, interference with speech and communication, pain and injury, and temporary and permanent hearing impairment. Prolonged exposure to noise contributes to overstimulation of the hearing which result in noise-induced hearing loss (NIHL) and it is going to bear unobserved for years since it is estimated that individuals lose about 28 % of hearing before becoming aware of the problem.[3] According to the American college of occupational and environmental medicine, occupational noise-induced hearing loss (ONIHL) develops gradually over a period of time as a result of continuous or intermittent noise exposure. Dental professionals are at an exaggerated risk for developing ONIHL. The National Institute for Occupational Safety and Health (NIOSH) has known noise together of the ten leading causes of work-related diseases or injuries.[3]

History

Use of ultrasonic scaling devices have become a staple in today's treatment of periodontal disease behind solid evidence. The use of ultrasound in dentistry was proposed by Catuna (1953) for the method of cutting teeth. Following this, development for ultrasonic cavity preparation became redundant due to the introduction of the rotary drill (street 1959), further work undertaken by Zinner (1955) showed that ultrasound could be used to remove deposits from the teeth. In 1960, McCall & Szmyd stated that ultrasonic instruments were an acceptable alternative to hand scalers as they were found to be as effective in the removal of calculus and ultrasonic scaling became an accepted procedure.[4]

Sources of noise in dental office

Dental offices have several sources of noise together with produced by dental equipment and ones produced by gadgets used for patient comfort. High-speed turbine hand pieces, low-speed hand pieces, high-velocity suction, ultrasonic instruments and cleaners, vibrators and other mixing devices, and model trimmers are the sources of dental sounds which are potentially damaging to hearing. Kilpatrick has listed the decibel ratings for various office instruments and equipment, which amount to 70–92 dB for high-speed turbine handpieces, 91 dB for ultrasonic cleaners, 86 dB for ultrasonic scalers, 84 dB for stone mixers and 74 dB for low-speed handpieces.[1] However, the audible sub-harmonics of the ultrasonic primary frequency are the frequencies of concern. These are produced due to sympathetic resonance of various components of the ultrasonic equipment which may include the cleaning tank, the enclosure panels, lids and other features. Pumps, blowers, and other ancillary equipment also contribute to the overall noise produced by the unit.

In a study done by Mojarad et al, it had been found that the maximum noise level in dental offices, although often beneath the damaging noise level for the human ear, is very close to the limit of hearing loss (85.0 dB).[6]

Effects of the noise produced
The frequencies produced from the use of ultrasonic devices are capable of not only inducing hearing loss, but it causes other nonauditory effects on the operator. Various auditory and nonauditory effects caused are:

1. Auditory effects
The ultrasonic devices operate at frequencies ranging approximately 20,000 vibrations per second to 50,000 vibrations per second and it emits sound in the range of 70–120 dB at a frequency of 25,000 hertz. It is associated with hearing loss risk in approximately 51% of dental professionals.[2] According to the American college of occupational and environmental medicine, occupational noise-induced hearing loss (ONIHL) develops gradually over a period of time as a result of continuous or intermittent noise exposure at about 2,000 to 4,000 hertz. There are reports of causing auditory fatigue at 90db or 4000 hertz, deafness- temporary at 4000-6000hz and permanent deafness at 100db.[1] The immediate, temporary auditory changes accumulate upon each noise exposure and play a key role in the development of permanent hearing impairment.

According to reports from occupational safety and health administration (OSHA) just 8 hours of continual exposure to a noise level of 85 decibels is permissible daily.[3] Several studies have tested the noise produced in dental practice that could exceed the occupational safety and health act (OSHA) standards. Ahmed et al stated that “noise exposure to a loudness of ≥ 85 dB for about 8 hours on daily basis can produce permanent hearing loss.”[7]

According to a study done by Chopra et al in 2016, negative auditory effects occurred immediately after exposure to high- frequency noise from ultrasonic scalers.[2]

There is temporary loss of hearing acuity is also known as temporary threshold shift (TTS). It most commonly occurs because of unceasing contraction of stapedius and tensor tympani muscles in the ear in response to high-frequency sound. This is the protective involuntary ear muscle contraction in response to high-frequency sound stimuli known as acoustic reflex. This facilitates acclimatization of ears to a noisy environment and prevents further ear damage. The prolonged contraction of ear muscles leads to spasm that manifests as pain, tinnitus or a ringing sensation in the ears. The TTS tends to disappear in 16 to 48 hours after exposure to loud noises and the ears’ function return to normal, but there is some amount of permanent damage that often takes place. The exposure to continuous or periodic noise causes a dynamic state of injury, degeneration and/or repair in the sensory cells of the inner ear. With moderate levels of exposure over long durations, such as those occurring in a dental unit (i.e. ≤ 100 dB), a few sensory hair cells degenerate within the organ of corti. Such nonfunctioning or injured cochlear hair cells are termed ‘dead holes.’ Dead hole formation is a gradual process, the rate of which depends upon the clinician’s auditory history. With each exposure to high-intensity sound, the number of dead cells increases. However, the injury persists as an undiagnosed condition for many years, since the individual does not perceive any pain or recognize minor changes in hearing acuity. Even with the presence of dead holes, hearing is maintained by the presence of remaining sensory cells in the inner ear. The hearing loss is noticed only when the number of remaining cells is insufficient to provide adequate hearing sensation. This is known as a state of permanent threshold shift or Permanent hearing loss. The permanent shift results in irreversible damage to the inner ear with complete loss of cochlear hair cells.[2,7] The immediate, temporary auditory changes accumulate upon each noise exposure and play a key role in the development of permanent hearing impairment.

Nonauditory effects
Apart from the unrecognized hearing loss, there could be various nonauditory effects which can impact dentist’s lifestyle leading to reduced quality of life because of impaired hearing ability. It may also affect communication and performance, which may include isolation, annoyance, difficulty concentrating, and accidents. Stress, muscle tension, ulcers, increased blood pressure, and hypertension could be other associated effects. There has been reports of occurrence of increased cardiac pulse, headache, annoyance, irritation, fatigue and speech misinterpretation among clinicians after exposure to loud noises. However, the nature, degree and rate of progression of auditory and non-auditory damage varies among dentists depends on the individuals’ age, physical condition and genetic susceptibility. A study in Saudi Arabia revealed that 16.6% of dental practitioners suffered from tinnitus, 14.7% experienced difficulty in speech discrimination, and 63% had difficulty with speech discrimination in background noise.

Degree of risk to the individual dentists depends on several factors:
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 dentist 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.[9]

Other potentially hazardous effects associated with the use of ultrasonic follows:

Vibration hazards- It can cause disruption in the blood flow to the fingers, caused by the vibration that is passed from the drill through to the hand leading to "white finger" or "acrocyanosis" because of the large amplitudes produced by pneumatic drills.[10]

Thermal pulp- The ultrasonic scaler produces an increase in temperature, and this heating may be due to frictional heating due to contact between scaler and tooth, direct temperature application by the irrigation fluid and acoustic energy absorption of ultrasound transmitted into the tooth. If sufficient heat reaches the pulp during dental procedures, it can lead to vascular injury and tissue necrosis (Nyborg & Brannstrom 1968).[4] 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.[10] An in vitro study demonstrated that under normal scaling conditions with the irrigation flow rate set at 20ml/min the temperature rise should not exceed 81c (Walmsley et al. 1986).[4]

Aerosol- The aerosol production could be hazardous to health (Suppipat 1974). In those dental clinics where ultrasonic scalers are being used, there is an increased number of airborne bacteria, which increases the potential for the spread of infection between patients and between patient and operator.[4]

Root surface removal by ultrasonic- 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.[9] In fact, overzealous root planning removes important protein components such as bone morphogenetic proteins and slows down critical fibrous attachment from bone to root.[10]

Auditory functions evaluation

The evaluation of auditory functions could be done by the:

1. **Pure tone audiometry (PTA) test-** It is generally the first quantitative hearing test that is performed to assess the nature and degree of hearing loss in adults and children over 4 years of age to properly plan the most appropriate intervention because this test determines the faintest tones a person can hear at selected frequencies from low to high.[8,2,7] This test indirectly reflected the middle ear status by assessing changes in the ear canal volume, middle ear pressure and stapedial reflex.
2. **Tympanogram or reflexometry test-** This test indirectly reflected the middle ear status by assessing changes in the ear canal volume, middle ear pressure and stapedial reflex.
3. **Otoacoustic emission (OAE) test-** It permits the early detection of inner ear abnormalities that are associated with a wide variety of diseases and disorders, including non-pathologic etiologies, such as noise exposure and aging. Changes in outer hair cell length generate energy within the cochlea that contributes to hearing sensitivity and the ability to distinguish small differences in the frequencies of sounds.[7,8]

Noise control in dental operatory

According to the OSHA, the maximum daily tolerable duration of exposure to noise with a frequency of 90 db is 8 h, 93 db is 4 h, 96 db is 2 h, 99 db is 1 h, 102 db is 30 min and 105 db is 15 min. Therefore, dentists should plan their work schedule depending upon the maximum frequency of noise exposure so as to minimize the exposure. Also, care has to be given when the sound level doubles, the time spent in a noisy environment should be reduced by half as recommended by NIOSH (National Institute of Safety and Health). Routine monitoring has to be done in the dental operatory and necessary measures to reduce excessive noise exposure. The recommendation of the ADA council on dental materials and devices include the following: preventive measures for noise attenuation should be directed in three areas, optimum maintenance of rotary equipment, reduction of the ambient noise level in the operatory and personal protection through the use of ear plugs.

Measures to be followed by dentists

1. The dentist should maintain a proper distance from the operating field. Kilpatrick recommends the distance from the dentist's eye to the patient's mouth to be 14 inches, i.e. about 35 cm.
2. Periodical audiometric tests should be carried out for prevention of hearing loss.
3. During the procedure, ears should be protected by a cotton ball saturated with a lubricant such as olive oil, or insertion of noise-excluding ear plugs into the ear canal (e.g. Audiocups).
4. The duration of dental procedures, the interval between each noise exposure and genetic predisposition to hearing damage upon exposure should also be evaluated.
5. A good rest period between successive noise exposures may help to recover some injured sensory cells and may restore hearing threshold.[2]
6. Moreover, dental school curricula must include the education about the different occupational hazards.[8]

Measures to be followed in the operatory

1. If possible, compressors have to be placed outside dental office or in an isolated area.
2. The dental surgery can be made more acoustically acceptable by minimizing the hard surfaces that allow echo of sound.[4]
3. Control of transmission is achieved by sound absorbing material wall resilient floors, sound proof acoustical ceiling, sound-dampening materials ought to be used for finishing the walls and ceilings of offices.[1]
4. The handpiece should also be well maintained, as old and poorly maintained equipment emits sound of higher intensity.
5. Additionally, dentists should avoid simultaneous use of several instruments, have an acoustically protective ceiling of tiles and laboratory walls with sound-absorbing materials as well as carpeted floors to reduce any ambient noises and reverberations in the surgery.

Active Noise Control (ANC)- This is an active method to reduce the noise pollution in dental setup which employs the use of specially designed headphones, the di-15, for the patient and the dental staff.[6] It is small and adaptable earpiece, powered by a tiny hearing aid battery, which lasts about two weeks and a noise reduction rating of n25. This functions as the custom electronic circuitry compresses sound when it reaches a dangerous noise level, but stops when safer noise levels are resumed thereby allowing the dental professional to resume normal conversations.[2]

Also, passive method of hearing protection devices (HPD), ie, earplugs could be used to protect ears from loud noises. It is a made of foam, molded polyurethane, and silicone which ultimately, protects the ear but do not allow the dental professional to hear his/her patients effectively. This device provides better outcome than an older alternative of putting cotton into the ear, as it reduces decibel ranges from 25 db to greater capacities based on their specific noise reduction ratings of n25 to n33. A noise reduction rating of n25 has the capacity to reduce the decibel levels by 25, while a noise reduction rating of n33 will have a superior capacity to reduce damaging noise levels. Also, custom earplugs made at an audiologist are the best way to obtain using a passive device.

Furthermore, continuing education programs should be provided in raising awareness about the risk of hearing loss among dental personnel and possible methods for its prevention.

CONCLUSION

High levels of noise produced by various dental hand-pieces and equipment are potentially hazardous to personnel who work in such an environment for a prolonged period ie, dentists and dental auxiliaries. Therefore, it becomes necessary to assess the levels of noise from such equipment in a dental operatory and take appropriate measures for its prevention. Oral health care professionals need to be aware of the potential dangers of occupational noise exposure, the leading cause of noise-induced hearing loss in the country.

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