An Assessment of the Effect of Sound Produced in a Dental Clinic on the Hearing of Dentists

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Objective: To assess the effect of sound produced in a dental clinic on the hearing of dentists in a dental school.

Materials and Methods: Thirty-two dentists were evaluated for changes in their hearing thresholds at the Speech and Audiology Department, Manipal College of Allied Health Sciences, Manipal, India. Middle Ear Analyser (MEA), Pure Tone Audiometry (PTA) and Oto-Acoustic Emission (OAE) were used to evaluate changes in the hearing thresholds.

Results: There was a change in distortion product (DP) amplitude (temporary shift) in all frequencies. Statistically significant changes were found in the 6 kHz and 4 kHz ranges in the left ear and 6 kHz in the right ear. There was a larger DP shift in the left ear than in the right ear. A comparison of the hearing thresholds of males and females showed a significant difference of 3 kHz in the left ear, where males had a higher hearing loss.

Conclusion: There were shifts of hearing threshold at 6 kHz and 4 kHz. The danger to hearing from dental clinic working environment in a dental school cannot be underestimated.

Key words: dentists, hearing loss, India, noise-induced hearing loss

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Noise is often defined as ‘unwanted sound’, but this definition is subjective because of the fact that one man’s sound may be another man’s noise.

A high-pitched, whining noise can be annoying even when it occurs infrequently. It is not surprising, then, that since the advent of high-speed dental drills, ultrasonic scalers and suction systems, dentists have complained about the noise to which they are exposed during a typical working day. Concerns have been voiced that constant exposure to this noise may be harmful to the dentist’s hearing. This led to interest in the subject of noise-induced hearing loss (NIHL).

Mittelman (1959) warned the profession of the health hazard caused by the whine of the turbine. His primary concern was that the vibrations per second could cause ‘definite irreparable damage over a period of time’. He believed that it made sense to take precautions to safeguard hearing.

Taylor et al (1965) concluded that although the newer types of turbine drills were quieter than the older ball-bearing types, a definite hearing loss occurred at high frequencies in a group exposed to drill noise. The dentist, who had been exposed to drill noise for 3 to 7 years, demonstrated a significant noise-induced threshold shift in the 6-kilocycles/second and 4-kilocycles/second frequency region that would be un-

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detected by the dentist and that did not constitute a social handicap. However, continued exposure caused 'gradual encroachment on the upper frequencies of the speech range'.

The American Dental Association's Council on Dental Materials and Devices (1974) recognised that extended exposure to the noise from ultra-high-speed cutting instruments could cause auditory damage. However, the council believed that age and the physical condition of the individual, frequency of exposure, intensity of loudness, length of exposure time and intervals between exposures were factors to consider. Anything higher than 1 kHz was considered dangerous.

Wilson et al (1990) studied the question of whether dentists were at greater risk of experiencing hearing loss than the rest of the population, and found a cause-and-effect relationship between hearing loss and the use of dental drills.

The objective of the present study was to assess the effect of sound produced in a dental working clinic in a dental school on the hearing of dentists.

MATERIALS AND METHODS

A total of 45 dental students (42 right-handed and 3 left-handed dentists) of Manipal College of Dental Sciences, Manipal, who consented for the study were preliminarily tested. Of these, 32 subjects (23 females and 9 males) fulfilled the inclusion criteria. Those subjects who had a cold, cough, or ear blockage in the previous week, middle ear (i.e. diaphragm, ossicles etc.) in abnormal condition, or subjects with abnormal hearing thresholds (normal, 0–25 dB[a]; Roeser et al, 2000a) were excluded. All subjects were 20–30-year-old dentists. The study was approved by the Ethics Review Committee of the Institution.

Examinations took place in the Speech and Audiology Department, Manipal College of Allied Health Sciences. Hearing evaluation procedures were in a sound-proof room.

Middle Ear Analyser (MEA) test

The MEA test was used to rule out middle ear abnormality. The GSI TympStar instrument (Guymark UK; designed to meet ANSI S3.39, ANSI S3.6, IEC 645-1, and IEC 1027) was used.

[a]**Decibel:** the unit of sound. The loudness of sound is measured in decibels (dB). The decibel scale is not logarithmic on base e, but on base 10, which means that a 10 dB increase is a 10-fold increase in noise. 2 dB indicates double the noise level.

The following values were considered (Roeser et al, 2000b):

- Static compliance: 0.30–1.70 mS (millisiemens);
- Ear canal volume[b]: 0.9–2.0 cm^3;
- Middle ear pressure[c]: -100–100 daPa (decapascal);
- Gradient/tympanic width[d]: 51–114 daPa.

Pure Tone Audiometry (PTA)

PTA was used to evaluate hearing thresholds using a GSI-61 clinical audiometer. Normal hearing threshold was considered 0–25 dB (Roeser et al 2000a).

Oto-Acoustic Emission (OAE)

OAE[e] was used to evaluate hearing using Master OAE, by which values of distortion product (DP) amplitude were obtained. The DPOAE[f] was considered present if its amplitude was 3 dB or more above the level of the surrounding noise floor or if its amplitude exceeded two standard deviations above the mean noise level (Ward and Holmberg, 1969).

OAE and MEA are objective tests in which a probe is inserted into subject's ear and the respective instruments pick up the responses. Subjects are instructed not to swallow, move the head or talk during the test.

[b] **Ear canal volume:** measured in cm^3, indicates the volume from the probe tip to the tympanic membrane at a pressure of +200 daPa. Volume changes from infants to adults, and also in males and females, and in pathologies. Compliance peak, expressed in daPa, indicates the amplitude of the peak. This desribes the stiffness and mobility of the tympanic membrane. Static compliance of the normal middle ear varies as a function of age and sex. The range is 0.3 to 1.75 daPa.

[c] **Middle ear pressure:** measured in cm^3, indicates the pressure at which equalisation occurs on both sides of the tympanic membrane. It also indicates the pressure at which peak compliance or maximum mobility is attained. This corresponds to the value on the horizontal axis of the graph. Middle ear is an air filled cavity and to maintain health, air in the middle ear must be at the same atmospheric pressure as that outside the ear. Air reaches the middle ear via the Eustachian tube, which is connected to the back of the throat. Air passes through this tube to equalise pressure. In Eustachian tube dysfunction, the pressure falls below -100 daPa.

[d] **Gradient:** expressed in daPa, is the tympanometric pressure width at 50% of the compliance peak. Infants may show higher gradient values due to the mobility of their ear canals.

[e] **Oto-Acoustic Emission:** used to check the function of the tiny hair in the cochlea. The faint sound made by the hairs in response to sound is called the Oto-Acoustic Emission. It is measured in two ways: spontaneous and evoked.

[f] **DPOAEs** are evoked OAE and are produced by normal cochlea when two primary acoustic signals are played to the cochlea at frequency f1 and f2 (f2 is at a higher frequency than f1) simultaneously. The distortion product is generated in the cochlear region when the two waves overlap. DPOAE is difficult to measure because of the presence of background noise from equipment (e.g. cooling systems or fans within a sound booth), or from the individual being tested (e.g. resonating noise from the person's breathing or a vascular noise trapped within the closed ear canal). A high noise floor will interfere with measurement of the DPOAE response. Any response at and above 6 dB is considered normal emission.

Table 1 Change in distortion product (DP) amplitude (temporary shift) from morning to afternoon at various frequencies

	Frequency (kHz)	N	Mean change in DP amplitude at the given frequencies (dB)	p value
Right ear	2	32	0.3500	0.679
	3	32	1.6906	0.074
	4	32	1.8344	0.071
	6	32	2.9719	0.003
	8	32	0.6563	0.520
Left ear	2	32	1.1031	0.310
	3	32	1.8438	0.099
	4	32	2.700	0.033
	6	32	3.0156	0.021
	8	32	-0.05625	0.954

p≤0.05, statistically significant

Table 2 Comparison between males and females for change in distortion product (DP) from morning to afternoon for right and left ear

	Right ear					Left ear				
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Male mean (SD)	1.4556 (4.8143)	3.0778 (7.3092)	0.9889 (8.1072)	3.9000 (7.4735)	-0.2778 (7.9997)	3.0222 (6.6183)	5.6556 (7.9629)	6.2556 (10.2455)	4.1333 (9.3782)	0.1222 (3.8101)
Female mean (SD)	-0.0826 (4.7431)	1.1478 (4.1329)	2.1652 (4.3536)	2.6087 (4.3575)	1.0217 (4.6943)	0.3522 (5.7841)	0.3522 (4.6674)	1.3087 (4.5168)	2.5783 (6.0735)	-0.1261 (6.0993)
p value	0.402	0.367	0.414	0.722	0.615	0.285	0.038	0.390	0.916	0.900

p≤0.05, statistically significant; SD, standard deviation

OAE is more sensitive even for mild cochlear damage; it is faster and more objective than PTA.

While all the three tests were used to satisfy the inclusion criteria, OAE was used for comparison before and after carrying out dental procedures.

All the subjects who satisfied the inclusion criteria were right-handed dentists. Thirteen dentists were excluded, of which seven dentists had a cold and a cough in the previous week and six were found to be already suffering from some degree of hearing loss. Unfortunately all the three left-handed dentists evaluated did not satisfy the inclusion criteria.

Subjects were examined in the mornings before the start of the clinical sessions. Those with normal hearing (as evaluated by the tests) were included in the study and were asked to perform their routine dental procedures on patients. The subjects were re-examined after the clinic hours on the same day.

SPSS version 10 statistical software was used for statistical analyses. The difference between morning and afternoon DP amplitudes for 8 kHz, 6 kHz, 4 kHz, 3 kHz, 2 kHz, was evaluated using paired *t*-test. To evaluate the gender differences, Mann-Whitney U test was used. P ≤ 0.05 was taken as statistically significant.

RESULTS

Twenty-three females and nine males fulfilled the inclusion criteria and were included in the study. The age range was from 20 to 30 years. The average age of the study population was 26 years. All the subjects were right-handed clinicians.

On evaluation, although there was change in DP amplitude (temporary shift) in all frequencies, statistically significant changes were found in 6 kHz and 4 kHz frequencies in the left ear and 6 kHz in the right ear. There was more DP shift in the left ear than in right ear. All the other frequencies tested were found to cause no significant temporary shift in either ear (Table 1).

When the hearing thresholds for males and females were compared, there was no statistical difference ($p \leq 0.05$), except at 3 kHz in the left ear, where males had more hearing loss than the females (temporary threshold shift) (Table 2).

DISCUSSION

The effect of noise on the hearing of dentists has a special significance in a dental school environment. Unlike a private dental practice, the issue of noise generated from other students' workstations, and from other departments leading to a constant passive exposure to noise cannot be ruled out. The student dentist doesn't necessarily have to be working on a patient to get exposed to this noise on a daily basis.

Different opinions have been expressed about the effect of the noise that is generated by a high-speed drill on the dentists' hearing acuity. Some investigators have found no evidence that performing dental procedures is detrimental to hearing (Ward and Holmberg, 1969), yet others have found a significant hearing loss (Skurr and Bulteau, 1970).

To exclude hearing loss due to age or presbycusis among the study population, those above 30 years of age in the study population and those with any kind of hearing loss were excluded form the study. Being left-handed is considered a taboo in Indian culture and this might explain the negligible number of left-handed dentists among the study population.

Most previous studies have taken into consideration high-speed handpieces only (Kessler, 1960; Hopp, 1962; Norman, 1963; Cantwell et al, 1965; Taylor et al, 1965; Von Krammer, 1968; Ward and Holmberg, 1969; Skurr and Bulteau, 1970; Weatherton et al, 1972; Franco et al, 1978; Sheldon and Sokol, 1984; Merrell and Claggett, 1992). In the present study all the instruments in a dental clinic were considered, such as air-rotor, ultrasonic scalers, suctions systems, and other surgical instruments. The dentists were asked to perform their normal clinical activity and not just use the drill. The treatment performed varied from scaling and root planing to periodontal surgery, and from Class I cavity preparation to root canal treatments.

Ward and Holmberg (1969) suggested that drill noise could not possibly affect frequencies below 3 kHz. Only 2, 3, 4, 6, and 8 kHz were checked in the present study.

The noise exposure pattern to which the dentist is exposed varies widely from day to day and depends on the nature of the practice. In the present study, the subjects were interns and postgraduate students. They performed treatment on patients as and when the patients presented.

Weatherton et al (1972) believed that the amount of noise exposure was probably limited in a dental school setting, whereas in private practice a dentist may see more patients and work a greater number of hours. It would appear that the chances of a private practitioner suffering from hearing loss are greater.

Zubick et al (1980) demonstrated that right-handed dentists exhibited greater hearing loss in the left ear. In the present study the right ear showed a statistically significant shift in distortion product amplitude at 6 kHz and the left ear at 6 kHz and 4 kHz, i.e. more hearing loss was evident in the left ear. This may be due to fact that the head acts as a shadow and leads to attenuation of sound intensity by about 10–15 dB on the left-hand side. This attenuation is greater for higher frequencies.

Taylor et al (1965) demonstrated a significant noise-induced threshold shift in 6 kHz and 4 kHz frequency regions, similar to the results of the present study. The authors stated that at these frequencies the effects would be undetected by the dentist and would not constitute a social handicap. However, continued exposure caused 'gradual encroachment on the upper frequencies of the speech range' (Merrell and Claggett, 1992).

In the present study, it was found that there was shift in DP amplitude (temporary shift) for a particular day. By this we can also predict susceptibility to NIHL in dentists and provide them regular hearing evaluation by an audiologist as previously recommended (Acoustical Solutions, 2006).

Some researchers have reported noise levels of 100 dB with air turbines (Wilson et al, 1990). Daily cumulative drill noise of 12–45 minutes falls within the recommended Occupational Safety and Health Administration (OSHA) guidelines, which allows 8 hours of exposure to a 90 dB sound pressure level stimulus (Wilson et al, 1990). However, older drills produce 100 dB or more, and the allowable exposure durations are reduced to approximately 2 hours per day, according to the OSHA guidelines (Wilson et al, 1990).

The OSHA recommend that hearing protectors must be available to all workers exposed to 8-hour TWA[g] (time-weighted average) noise levels of 85 dB or above (Acoustical Solutions, 2006). This requirement ensures that access to protectors is available, as a means of preventive protection for the dentist.

[g] **TWA** (time-weighted average): the average dB exposure projected over an 8-hour day, using the A weighting network. TWA should be measured for all employees routinely exposed to hazardous noise.

CONCLUSIONS

The small but consistent shifts of hearing threshold at 6 kHz and 4 kHz found in the present and other studies indicate that, although the danger to hearing from dental clinic in a dental school environment is small, it is not negligable.

It would be useful to plan a longitudinal study in which the same dentists are tested at three-year intervals; exposure to drills, scalers, suction systems and other auditory hazards should be estimated at each test. Only then can the question of danger of dental clinic noise be better answered.

Finally, the low risk to hearing from noises in the dental surgery should be kept in perspective, relative to the much greater potential auditory hazards from various non-occupational noises to which all dentists are exposed.

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