

Hearing loss associated with long-term exposure to high-speed dental handpieces

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The purpose of this study was to record and compare audiometric pure tone thresholds of dental clinicians (DCs), dental professionals (DPs), and dental students (DSs); determine the percentage of these groups who use hearing protection devices while at work in the clinic; and measure the sound intensities generated by a few representative high-speed handpieces while they are being used on patients. Participants included DCs who regularly used these handpieces ($n = 16$), DPs who did not use these handpieces ($n = 13$), and DSs ($n = 8$). A questionnaire was used to collect demographic information, assess occupational and recreational noise exposure, and note the level of hearing protection used. A sound level meter was used to measure the sound intensity

generated by dental instruments near a clinician's ear. Results showed that DCs who regularly used high-speed handpieces had worse hearing than did members of the other study groups. These results indicate that the implementation of protective strategies should help to reduce the prevalence of occupational hearing loss among DCs.

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The cause-and-effect association between loud noise exposure and hearing loss is well established.¹ The *National Institute on Deafness and Other Communication Disorders* website reports that approximately 15% of Americans between the ages of 20 and 69—26 million Americans—have high-frequency hearing loss that may have been caused by exposure to loud noises at work or in leisure activities.² In an attempt to reduce workers' risk of developing noise-induced hearing loss (NIHL), the *United States Occupational Safety and Health Administration* (OSHA) established safety standards related to noise exposure.³ Originally published in 1983, the standard states that the maximum permissible exposure limit (PEL) in an 8-hour day should not exceed 90 dBA SPL (decibel sound pressure level using an A-weighted scale).³ OSHA's standard uses a 5 dB exchange rate, meaning that the PEL for 95 dB noise is reduced to 4 hours, the PEL for 100 dB sound is 2 hours, and so on. However, these standards are applied to large populations of people. Within these populations, some individuals are more susceptible to noise-induced auditory dysfunction than others.

Sound intensity generated by high-speed dental handpieces

It has been suspected for decades that high-speed handpieces might contribute to the hearing loss exhibited by some dental

clinicians (DCs). Consequently, several investigators have measured the sound intensities generated by these devices.⁴⁻⁸ Barek et al analyzed the sound intensities generated by high-speed handpieces in both the audible (<20,000 Hz) and ultrasonic (>20,000 Hz) frequency ranges.⁴ The authors reported that the MICRO-MEGA brand handpiece (MICRO-MEGA SA) generated a maximum of 95 dB SPL in the audible range, but 112 dB SPL at 50,000 Hz. The Siemens (Siemens Corporation) and KaVo (KaVo Dental) brand handpieces generated high intensity sounds (101 and 115 dB SPL, respectively) in the ultrasonic frequency range. Barek et al concluded that all these instruments "reach levels that may provoke short- or long-term negative physiological disturbances and hearing damage risk."⁴

Kilpatrick listed the sound intensities generated by high-speed handpieces (70-92 dB SPL), ultrasonic scalers (86 dB SPL), stone mixers (84 dB SPL), and low-speed handpieces (74 dB SPL).⁵ Sorainen & Ryttonen reported that the A-weighted sound pressure level generated by a variety of handpieces ranged from 76 to 89 dB SPL.⁶ In Portugal, Sampaio Fernandes et al measured sound levels in different areas of a dental school and reported intensities ranging from 60 to 99 dB SPL.⁷ Kadanakuppe et al recorded a strikingly similar range of sound levels (64-97 dB SPL) at a dental school in India.⁸

A key question is whether or not these reported sound intensities can cause hearing loss. The physiological effects of sound on hearing depend on both the intensity of sound and the duration of exposure.^{2,3} Because dental professionals (DPs) do not use high-speed handpieces or other instruments continuously during the workday, they do not usually exceed OSHA's PEL or the more conservative PEL (85 dB) recommended by the *National Institute for Occupational Safety and Health*.^{3,9} While considering these recommendations, it is important to remember that Park cautioned, "There is a danger, however, of finding comfort in the results of group studies and group standards. Every group is made of individuals, and individuals react to different things in different ways at different times."¹⁰ Merrell & Claggett expressed similar sentiments: "Ears differ in their susceptibility to damage through exposure to noise, thus exposure in a common work environment may cause hearing loss in one person and not in another."¹¹ Since most people do not know their personal susceptibility to loud noise exposure, Park—along with Merrell & Claggett and others—recommended that DPs implement strategies in the workplace to reduce their risk of occupational hearing loss.^{10,11}

Evidence of noise-induced hearing loss among dental professionals

More than 12 published studies have assessed the hearing of DCs to determine

if they have significantly worse hearing compared to age-matched individuals who are not regularly exposed to the noise generated by high-speed dental handpieces. One of the early studies was conducted in Scotland by Taylor et al.¹² These authors tested the hearing of 30 dentists who used air turbine drills in their practices. The researchers concluded that the dentists exhibited elevated auditory thresholds at 4000 and 6000 Hz, which is a characteristic of noise-induced hearing loss.

Zubick et al compared the pure tone hearing thresholds of 11 dentists (average age 48 years) with those obtained from 80 physicians (average age 45 years).¹³ The authors found that the auditory thresholds for the dentists were slightly worse than the physicians' thresholds at 4000 and 6000 Hz. They concluded that "there may be a cause and effect relationship between hearing loss and use of the high-speed dental handpiece."¹³

Wilson et al tested the hearing of 20 dental hygienists (mean age 43 years) who often used ultrasonic scalers and 20 dental hygienists who seldom used ultrasonic scalers (mean age 43 years).¹⁴ Their results indicated that the high-usage group had significantly worse thresholds for 3000 Hz tones compared to the low-usage group. Again, because elevated thresholds at 3000 Hz can indicate excessive exposure to loud sounds, it is possible that the noise generated by ultrasonic scalers contributed to the occupational hearing loss exhibited by these hygienists. Evidence of greater than expected hearing loss in DCs has also been reported by Fabry, Gijbels et al, Bali et al, and Messano & Petti.¹⁵⁻¹⁸

However, other researchers who tested the hearing of DCs concluded that noise generated in the clinic did not contribute to additional hearing loss.¹⁹⁻²¹ Obviously, controversy exists regarding the contributions of high-speed handpieces to NIHL in DCs. Attributing specific sources of noise exposure to hearing loss in adults is often difficult because of the many factors that contribute to auditory dysfunction: age, genetics, disease, and other sources of loud sound exposure. Each person's individual susceptibility to hearing loss from noise exposure should be considered when decisions are made regarding the implementation of hearing protection strategies in the workplace.

Table 1. Descriptive statistics of the study groups.

Group	n	Mean age in years (SD)	Gender (n)	Average number of years (SD) in profession
Dental clinicians	16	53.5 (12.0)	M (16), F (0)	22.3 (12.3)
Dental professionals	13	47.3 (11.5)	M (4), F (9)	21.8 (11.1)
Dental students	8	28.9 (3.4)	M (5), F (3)	2.8 (0.4)

Abbreviations: F, female; M, male; n, number; SD, standard deviation.

Use of hearing protection devices by dental clinicians

In 1974, the *American Dental Association (ADA) Council on Dental Materials and Devices* issued the report, *Noise Control in the Dental Operator*.²² The Council recommended that preventive measures for noise attenuation should include "personal protection through the use of ear plugs."²² Before and after publication of this report, many researchers and clinicians recommended that DCs utilize hearing protection devices (HPDs) when using noisy equipment or instruments in the clinic or laboratory.^{6,10,11,14,15,23-30}

Although the recommendation that DCs utilize HPDs while using noisy instruments has been made repeatedly during the last 4 decades, few studies of HPD implementation among them have been conducted. Serafini et al reported that only 1 of the 23 dentists in their study used HPDs at work.²⁹

Current investigation

This pilot study was undertaken to record and compare audiometric pure tone thresholds of DCs, DPs, and dental students (DSs); determine the percentage of DCs, DPs, and DSs who use hearing protection devices while at work in the clinic; collect data from DCs, DPs, and DSs regarding nonoccupational noise exposure; and measure the sound intensities generated by a few representative high-speed handpieces while they are being used on patients.

Materials and methods

Study participants were recruited and data were collected at the Oregon Health & Science University (OHSU) Dental School. Participants included DCs who regularly used high-speed handpieces

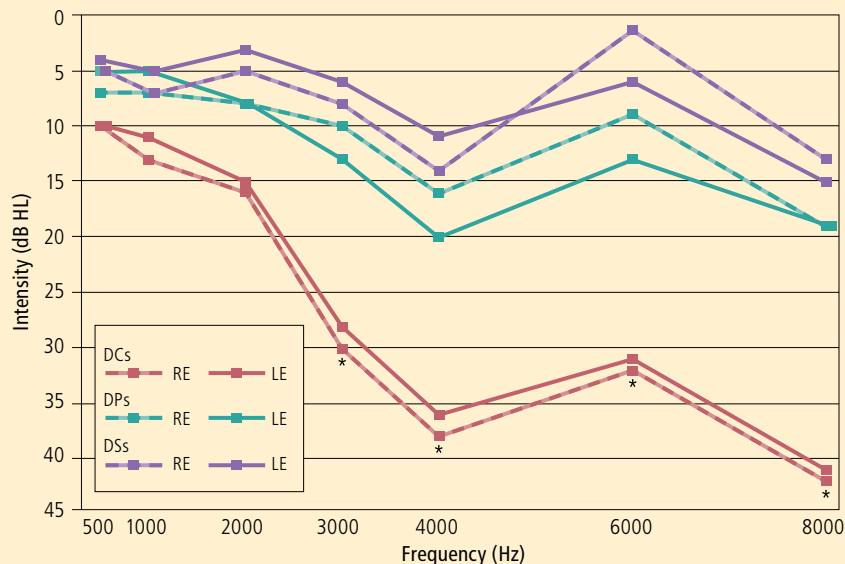
(n = 16), DPs who did not use high-speed handpieces (n = 13), and DSs (n = 8). Pure tone audiometric data were collected at 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz using a portable audiometer (Belton model 119, Belton) in a quiet room. A portable audiometer was used in order to make testing more convenient for the dental school faculty, staff, and students. Audiometric thresholds were later verified by retesting a subset of research subjects in a clinical sound booth. A questionnaire was used to assess occupational and recreational noise exposure, note any use of hearing protection, and collect demographic information. A Bruel & Kjaer Type 2250 sound level meter (Bruel & Kjaer Sound & Vibration Measurement A/S) was used to measure the sound intensity generated by dental instruments near each clinician's ear. Informed consent was obtained before any measurements or tests were performed. All research procedures were approved by the OHSU Institutional Review Board. Written informed consent was obtained from all study participants.

Results

Participants

Table 1 shows descriptive statistics for each of the study groups. The noise-exposed DC group included 15 dentists and 1 prosthodontist. The minimal noise exposure DP group included radiologists, radiology technicians, and clinic administrators. The third group comprised DSs. A 2-tailed *t* test revealed no statistically significant differences between the mean ages of the noise-exposed DCs compared to the DPs with minimal noise exposure ($P > 0.05$). The DSs were significantly younger than the members of the other groups.

Chart. Mean audiometric data for each group in the study.



Abbreviations: DCs, dental clinicians who routinely use high-speed handpieces (n=16); DPs, dental professionals who do not use high-speed handpieces (n=13); DSs, dental students (n=8); LE, left ear; RE, right ear.

*Thresholds at these frequencies were significantly worse in the DC group than in the DP and DS groups (see Tables 2 and 3 for details).

Table 2. Analysis of variance comparing audiometric thresholds across test frequencies.

Frequency	F	P value
RE 500 Hz	1.728	0.193
RE 1000 Hz	2.804	0.075
RE 2000 Hz	2.598	0.089
RE 3000 Hz	4.390	0.020*
RE 4000 Hz	4.807	0.015*
RE 6000 Hz	8.497	0.001*
RE 8000 Hz	8.313	0.001*
LE 500 Hz	2.148	0.132
LE 1000 Hz	3.103	0.058
LE 2000 Hz	2.292	0.116
LE 3000 Hz	3.993	0.028*
LE 4000 Hz	4.000	0.028*
LE 6000 Hz	4.351	0.021*
LE 8000 Hz	4.810	0.014*

*Designates clinical significance ($P < 0.05$). Abbreviations: RE, right ear; LE, left ear.

Audiometric results

The averaged audiograms for each study group are shown in the Chart. Audiometric thresholds collected via portable audiometer were verified by retesting a subset of 12 research subjects in a clinical sound booth. This verification process revealed that thresholds collected using the 2 methods agreed within 5 dB for all test frequencies, which is within the clinical standard of error for pure tone hearing sensitivity tests. The mean audiometric results for the group of noise-exposed DCs revealed a sloping high-frequency hearing loss. The group of DPs with minimal noise exposure had hearing thresholds within the normal range of hearing, but their thresholds were poorer compared to the DSs. A 1-way ANOVA and a Bonferroni correction for multiple comparisons showed a significant difference ($P < 0.05$) among the mean thresholds of the 3 groups (for both ears) from 3000 to 8000 Hz (Table 2). Post hoc testing revealed that the mean thresholds of the DC group were significantly worse compared to the DP and the DS groups for 4000 to 8000 Hz in the right ear

and approached statistical significance at 3000 Hz ($P = 0.055$ compared to the DP group; $P = 0.058$ compared to the DS group). Left ear data revealed significant differences from 3000 to 6000 Hz between the DCs and DSs, and significant differences between the DC group and the other 2 groups at 8000 Hz (Table 3). Audiometric mean thresholds for the DP group were not significantly different from the DS group in either ear.

Hearing protection device use

The use of HPDs in the OHSU dental clinics was rare, with only 1 of 16 DCs, 0 of 13 DPs, and 1 of 8 students reporting that they used earplugs in the workplace.

Nonoccupational noise exposure

In addition to work-related noise exposure (such as high-speed handpieces, suction devices, or ultrasonic scalers), many study participants also reported histories of significant exposure to loud sounds outside of the dental clinic. For example, several noise-exposed clinicians and other DPs served in the US military and were exposed to extremely

loud sounds—gunfire, artillery fire, and explosions—during training or combat. Some study participants also reported being exposed to recreational gunfire, fireworks, loud sounds from power tools, music, factory machinery, or farm equipment. Participants reported that they “sometimes” or “never” wore HPDs during these activities. None of the participants “always” wore HPDs in these situations. The primary source of noise exposure for the students was loud music—at concerts, nightclubs, or via personal stereo equipment. It is impossible to quantify the amounts of these exposures for individuals or study groups, but it is important to remember that nonoccupational noise was a factor in the hearing loss exhibited by some participants.

Sound intensities generated by high-speed handpieces

The Bruel & Kjaer sound level meter was used to measure the peak sound intensities (A-weighted) generated by instruments while they were being used during dental procedures. The sound meter’s microphone was positioned near

the clinician's ear that was closest to the handpiece during the procedure. The following peak sound intensities were recorded: Midwest Tradition High-Speed Handpiece (DENTSPLY International) with friction grip No. 2 round bur, 88-94 dB SPL; Micro-Mega High-Speed Handpiece with No. 4 round carbide bur, 98-102 dB SPL; and Cavitron Select Ultrasonic Scaler (DENTSPLY International), 92-98 dB SPL.

These sound intensities are high enough to contribute to cochlear damage and noise-induced hearing loss over time.^{2,3} Although the DCs' duration of exposure to these sounds might be relatively brief (as little as 30-45 minutes per day), the cumulative effects of such exposures over years or decades of practice might very well contribute to occupational hearing loss and/or tinnitus for some individuals. Additional sources of loud sounds in a clinic (such as suction devices or other instruments being used in nearby operatories) can also increase clinicians' total noise exposure and risk for developing NIHL.

Discussion

Because this was a pilot study with a relatively small number of participants, the results are considered preliminary. Potential confounding factors—including age and gender of participants, duration and type of handpiece usage throughout each person's career, and precise measurements of occupational and recreational noise exposure—were not controlled in this investigation. In spite of these limitations, the sloping high-frequency hearing loss exhibited by DCs in this study is consistent with long-term exposure to loud sounds. Measurements of sound levels generated by instruments in the current study revealed intensities that can contribute to the pattern of hearing loss observed in the DC group. However, age, genetics, and other sources of loud sounds also contributed to the hearing loss exhibited by subjects in this study. While hearing loss due to aging or genetic factors is not preventable, NIHL can be prevented by using HPDs in noisy environments.

The lack of HPD use by DCs and DSs in this study is not surprising considering their use (or lack thereof) in the workplace overall. Workers in noisy conditions—including industrial

Table 3. Multiple comparisons of audiometric thresholds at tested frequencies.

Frequency	Group	Groups	Mean difference	P value	95% confidence interval	
					Lower	Upper
RE 500 Hz	DC	DP	3.08	0.659	-3.12	9.27
		DS	5.00	0.266	-2.19	12.19
RE 1000 Hz	DC	DP	5.58	0.130	-1.12	12.27
		DS	5.63	0.231	-2.14	13.39
RE 2000 Hz	DC	DP	7.16	0.332	-3.85	18.18
		DS	10.63	0.131	-2.15	23.40
RE 3000 Hz	DC	DP	19.30	0.055	-0.31	38.92
		DS	22.19	0.058	-0.56	44.94
RE 4000 Hz	DC	DP	21.73*	0.036	1.12	42.34
		DS	23.75	0.052	-0.15	47.65
RE 6000 Hz	DC	DP	22.33*	0.012	4.19	40.47
		DS	30.94*	0.002	9.90	51.97
RE 8000 Hz	DC	DP	23.49*	0.008	5.22	41.75
		DS	29.83*	0.003	8.73	50.93
LE 500 Hz	DC	DP	5.07	0.238	-1.99	12.14
		DS	5.31	0.335	-2.88	13.50
LE 1000 Hz	DC	DP	6.64	0.091	-0.75	14.02
		DS	6.25	0.225	-2.32	14.82
LE 2000 Hz	DC	DP	6.23	0.612	-5.88	18.34
		DS	11.56	0.137	-2.48	25.61
LE 3000 Hz	DC	DP	15.12	0.134	-3.14	33.38
		DS	21.56*	0.045	0.39	42.73
LE 4000 Hz	DC	DP	16.64	0.156	-4.16	37.43
		DS	25.00*	0.040	0.88	49.12
LE 6000 Hz	DC	DP	17.48	0.106	-2.61	37.56
		DS	24.69*	0.035	1.39	47.98
LE 8000 Hz	DC	DP	22.09*	0.045	0.41	43.77
		DS	25.94*	0.041	0.80	51.08

*Designates clinical significance ($P < 0.05$). Abbreviations: DCs, dental clinicians; DPs, dental professionals; DSs, dental students; LE, left ear; RE, right ear.

and military environments—often have low rates of HPD utilization, even after they have been ordered to use the devices.³¹⁻³⁴ Reasons for not using HPDs during noisy dental procedures include discomfort, fear that HPDs will interfere with communication, inconvenience, negative feedback from coworkers or patients, and the belief that noise levels from dental instruments will not damage hearing. In fact, earplugs equipped with

filters (known as *musician's earplugs*) will not interfere with a clinician's ability to understand coworkers or patients. Custom-made musician's earplugs can be obtained from any practitioner who fits patients with hearing aids, such as an audiologist or hearing aid dispenser. Noncustom (and therefore disposable) musician's earplugs are also available. While these disposable earplugs may only provide minimal noise reduction (15 dB

of attenuation), it is enough to greatly reduce a clinician's risk of developing NIHL from the noise generated by handheld instruments.⁶ Patients can also be given the opportunity to wear disposable foam ear plugs during dental procedures. However, patients who are exposed to noise from dental instruments only occasionally have minimal risk of developing NIHL or tinnitus from this sound source.

Results from this study are consistent with the findings of previous studies that showed clinicians who operate dental handpieces or other loud instruments are at risk of developing NIHL. Multiple factors contribute to this risk, including variations in the frequency composition of the noise, the number of hours per week that handheld devices are used, and variations in sound intensity over time related to turbine speed and maintenance of the devices. Setcos & Mahyuddin described these and additional factors in a 1998 article.²⁶ It is unlikely that a DC's daily exposure to high-speed handpieces will surpass OSHA's PEL for an 8-hour workday. However, it is the authors' opinion that OSHA standards are probably not stringent enough and also do not take individual susceptibilities to NIHL or tinnitus into account.

Conclusion

To decrease their risk of developing NIHL, dental practitioners are encouraged to follow the recommendations by the ADA Council on Dental Materials and Devices, which states:

...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 (soundproofing, acoustical ceilings, baffle drapes, resilient floors, rational location of the compressor and other noise-making equipment), and personal protection through the use of ear plugs.²²

Additionally, the ADA Council recommended that

...practitioners concerned about the potential impairment should have an otologic examination and have an audiometric evaluation in a silent room to assess the

present condition. Noise levels in the individual offices should be studied with monitoring periods of more than a week. An audiometric evaluation should be made after a typical workday and again at the beginning of the next day to observe temporary threshold shift and apparent recovery. Annual tests of hearing should be taken.²²

To these recommendations, the authors of the present study suggest adding the caveat that hearing protection strategies should always be implemented during noisy recreational as well as occupational activities.

Regarding future research in this area, the authors concur with Hyson in recommending that additional studies should be conducted to investigate the hearing loss potential among students, faculty members, practicing dentists, and other dental staff members who work with air-turbine handpieces; to determine whether there is a correlation between the use of the air turbine and hearing loss; and to determine whether dentists and staff members should wear ear protection.³⁵ The following investigations could yield valuable information:

- Longitudinal studies of students, faculty members, practicing dentists, and hygienists to assess their hearing annually and to determine if they exhibit NIHL or tinnitus. Regarding tinnitus, Devlin & Leandro wrote about a clinician's personal experience:

I have been practicing dentistry for 15 years now. About 7 years ago, I developed tinnitus in my left ear. It is an annoying, high-pitched whine, sounding almost like a high-speed handpiece that runs 24 hours a day, 7 days a week. Although it was uncertain as to why I developed this condition, I wish that I had started wearing earplugs in dental school, and had continued the practice throughout my dental career.²⁸

- A large-scale study of the current hearing protection practices of DCs. This study should include questions regarding their attitudes and behaviors related to utilization of HPDs.
- A study to determine if specific educational interventions related

to hearing and noise exposure would affect the attitudes and behaviors of DCs regarding hearing loss prevention practices.

- A study to determine which HPDs are preferred by DCs.

Author information

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Manufacturers

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