

# Characterization of Hearing Thresholds from 500 to 16,000 Hz in Dentists: A Comparative Study

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## Abstract

**Introduction** High-level noise exposure in dentists' workplaces may cause damages to the auditory systems. High-frequency audiometry is an important tool in the investigation in the early diagnosis of hearing loss.

**Objectives** To analyze the auditory thresholds at frequencies from 500 to 16,000 Hz of dentists in the city of Curitiba.

**Methods** This historic cohort study retrospectively tested hearing thresholds from 500 to 16,000 Hz with a group of dentists from Curitiba, in the state of Paraná, Brazil. Eighty subjects participated in the study, separated into a dentist group and a control group, with the same age range and gender across groups but with no history of occupational exposure to high levels of sound pressure in the control group. Subjects were tested with conventional audiometry and high-frequency audiometry and answered a questionnaire about exposure to noise.

**Results** Results showed that 81% of dentists did not receive any information regarding noise at university; 6 (15%) dentists had sensorineural hearing impairment; significant differences were observed between the groups only at frequencies of 500 Hz and 1,000, 6,000 and 8,000 Hz in the right ear. There was no significant difference between the groups after analysis of mean hearing thresholds of high frequencies with the average hearing thresholds in conventional frequencies; subjects who had been working as dentists for longer than 10 years had worse tonal hearing thresholds at high frequencies.

**Conclusions** In this study, we observed that dentists are at risk for the development of sensorineural hearing loss especially after 10 years of service.

## Keywords

- ▶ noise induced
- ▶ dentist
- ▶ hearing loss

## Introduction

Noise is present in different environments of human society, including the workplace, and may cause irreversible damage to the human body.<sup>1</sup> Loud noise is present in dentists' workplaces, whether from the clinical equipment used, such as dental drills, suction tubes, amalgamators, air compressors (when located in the room), suction pumps, autoclaves, and air conditioners, or

from external sources, such as ambient noise including traffic from nearby vehicles and other urban noise.<sup>2–4</sup>

High-level noise exposure may damage the auditory system in dentists. Since the 1950s, some studies have shown high sound pressure levels in high-speed equipment in dentists' workplaces.<sup>5</sup> In 1959, the American Dental Association recommended periodic audiological evaluations for dentists due to noise exposure.<sup>6</sup>

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Many studies showed that dentists are at risk of developing noise-induced hearing loss (NIHL).<sup>7-10</sup> The damage caused by exposure affects the inner ear and causes an irreversible hearing loss. The auditory thresholds show a classic sign of NIHL in the audiometric notch at the frequencies in the range between 3 and 6 KHz.<sup>11-13</sup>

Because early diagnosis of NIHL is prioritized, additional audiological tests are used to add value to basic audiological evaluations; among them, high-frequency audiometry (from 8,000 Hz) is used.<sup>14</sup> Studies show that high-frequency audiometry is an important tool in the investigation of the basal cochlear response as well as an instrument that helps in the early diagnosis of NIHL.<sup>15-18</sup> Research using high-frequency audiometry has suggested that with increasing noise exposure and age on dentists, there is a decrease in auditory thresholds.<sup>9,19-21</sup>

As a result of these considerations, this study aimed to analyze the auditory thresholds at frequencies from 500 to 16,000 Hz of dentists in the city of Curitiba.

## Methods

This historic cohort study retrospectively tested hearing thresholds from 500 to 16,000 Hz in a group of dentists from Curitiba, in the state of Paraná, Brazil. The study took place from August to December 2011.

The dentists' time of professional practice was considered in the analysis. The auditory threshold of dentists was also compared with a group of subjects with the same age range and gender, but with no history of occupational exposure to high levels of sound pressure (control group).

This study was approved by the Ethics Research Committee, number 017/2008. The procedures were performed after each participant signed the informed consent form—TCLE (Resolution MS/CNS/CNEP, Number 196/96, October 10, 1996). Subjects were excluded if they had compromised middle ear or previous hearing damage.

To be included in the dentist group, the subject had to be an active dentist. To be included in the control group, subjects had to not be exposed to occupational noise and to be of the same sex and age as one of the dentists for paired data.

The group of dentists was composed of 40 subjects, 10 men and 32 women. The subjects' ages ranged from 23 to 61 years (mean 40.55 years, standard deviation 9.87 years, median 41.5 years) and time of practice was 1 to 39 years (mean 16.32 years and standard deviation 9.67 years). Subjects in the dentists' group worked 6 to 12 hours daily, but this variable was not considered in this study because accurate noise exposure assessments in hours/years are difficult in such cases. All participants were handed a questionnaire about noise exposure.

The control group had a total of 40 subjects. This group was composed of students and subjects from different professional activities who did not present noise exposure. They were all volunteers who were invited to participate in this study. For the analysis of the data, each subject from control group was matched one-to-one with someone from the group of dentists.

All 80 subjects submitted to ear canal inspection to rule out possible obstructions that could compromise the hearing test. All subjects were at acoustic rest for at least 14 hours before audiometry.

Pure tone hearing thresholds were tested by conventional audiometry (frequencies from 500 to 8,000 Hz using a Madson Itera II model audiometer (GN Otometrics Schaumburg, IL, USA), calibrated according to the International Organization of Standards 389/64 standards) and high-frequency audiometry with the same equipment but with HDA 200 headphones (Sennheiser, Old Lyme, CT, USA) with a sound intensity in decibels hearing loss (dB HL), frequency 9,000 to 16,000 Hz, calibrated according to the American National Standards Institute S3.6/69.

The hearing normality criterion was defined for aerial tone hearing thresholds up to 25-dB HL for the frequency rate of 500 to 8,000 Hz. In the case of changes in pure tone air conduction thresholds, pure tone audiometry was performed by bone conduction.<sup>22</sup>

For the analysis of high-frequency hearing thresholds (from 9,000 Hz), as there are no standardized normal results, we used the group of subjects not exposed to occupational noise (control group) for comparison with the group of dentists.

Statistical methods that enabled the determination of significant audiologic assessment between groups' results

**Table 1** Conventional hearing thresholds in the groups ( $n = 80$ )

Frequency (Hz)	Right ear					Left ear				
	Dentists		Controls		$p$	Dentists		Controls		$p$
	Avg	$\sigma$	Avg	$\sigma$		Avg	$\sigma$	Avg	$\sigma$	
500	15.12	3.84	9.00	5.09	0.0000 <sup>a</sup>	17.00	3.89	9.25	6.26	0.0000 <sup>a</sup>
1,000	12.00	5.04	8.50	5.91	0.0056 <sup>a</sup>	10.00	4.94	9.38	6.12	0.6164
2,000	9.25	6.36	7.38	5.43	0.1601	7.87	7.15	7.63	7.34	0.8778
3,000	7.38	7.59	6.75	6.06	0.6850	7.88	6.59	10.25	7.07	0.1241
4,000	9.62	9.63	7.75	7.07	0.3240	9.37	8.26	10.37	8.04	0.5847
6,000	18.63	12.86	12.75	9.27	0.0216 <sup>a</sup>	19.25	11.30	15.38	7.02	0.0691
8,000	15.75	13.71	10.63	8.49	0.0478 <sup>a</sup>	15.50	15.01	15.63	7.94	0.9630

Abbreviations: Avg, average;  $\sigma$ , standard deviation.

<sup>a</sup>Significant differences between the mean thresholds according to Student  $t$  test at a significance level of 0.05.

**Table 2** High-frequency hearing thresholds in the groups ( $n = 80$ )

Frequency (Hz)	Right ear					Left ear				
	Dentists		Controls		$p$	Dentists		Controls		$p$
	Avg	$\sigma$	Avg	$\sigma$		Avg	$\sigma$	Avg	$\sigma$	
9,000	20.13	16.96	17.37	16.41	0.4634	19.50	14.36	17.75	14.67	0.5913
10,000	22.00	18.36	20.50	17.39	0.7085	22.13	18.50	21.00	16.53	0.7750
11,200	25.63	18.75	22.38	20.41	0.4605	25.75	20.15	23.75	19.80	0.6555
12,500	24.25	22.49	22.88	22.73	0.7864	26.75	24.22	24.00	25.40	0.6216
14,000	26.13	21.50	30.00	23.53	0.4443	29.00	23.10	29.25	24.01	0.9623
16,000	34.63	21.73	33.13	21.41	0.7567	34.88	20.98	33.82	21.70	0.8271

Abbreviations: Avg, average;  $\sigma$ , standard deviation.

were used for data analysis, considering a 0.05 significance level (5%).

Descriptive statistics were applied. Student  $t$  test was used to compare the thresholds of the groups and the analysis of tonal hearing thresholds as a relation of time of service in years for dentists' group.

## Results

Forty dentists from Curitiba took the hearing tests and answered a questionnaire about exposure to noise in their workplace. We observed that 81% of dentists did not receive any information regarding noise during their academic training; however, 51% said they knew the effects of noise on health. All (100%) acknowledged the existence of noise in their workplace, and 54% believe that noise to be of medium intensity and 24% believe it to be of loud intensity. Only two dentists used hearing protection devices.

Six (15%) dentists had sensorineural hearing impairment, only 1 (2.5%) with unilateral hearing loss (left ear) and 1 (2.5%) individual with hearing impairment among the group not exposed to occupational noise.

Auditory thresholds for the 40 dentists were analyzed and compared with the group of 40 subjects not exposed to occupational noise. Comparison of hearing thresholds in conventional frequencies between groups is shown in ►Table 1. There were differences between the frequencies of 500 Hz in both ears and in 1,000, 6,000, and 8,000 Hz for the right ear; results were worse in dentists compared to controls.

The results of pure tone hearing thresholds at higher frequencies are shown in ►Table 2. No differences between the groups for the high frequencies were observed. To compare conventional and high-frequency auditory thresholds, dentists were separated into two groups: those with over 10 years of experience and those with less than 10 years, shown in ►Tables 3 and 4. Differences were noted between the frequencies of 2,000, 4,000, and 6,000 Hz for the right ear, and the average conventional auditory tone thresholds were worse among those with more than 10 years of experience.

There was no difference at all for frequencies in both ears, and those who had been working as dentists for longer than 10 years had worse tonal hearing thresholds at high frequencies.

**Table 3** Conventional thresholds among dentists with time in service of up to 10 years ( $n = 14$ ) and over 10 years ( $n = 26$ )

Frequency (Hz)	Right ear					Left ear				
	0–10 y		Over 10 y		$p$	0–10 y		Over 10 y		$p$
	Avg	$\sigma$	Avg	$\sigma$		Avg	$\sigma$	Avg	$\sigma$	
250	13.21	4.21	14.62	4.88	0.3705	18.21	5.41	15.19	5.00	0.0842
500	13.93	2.89	15.77	4.17	0.1503	17.50	5.10	16.73	3.14	0.5576
1,000	11.43	4.57	12.31	5.33	0.6051	10.36	4.14	9.81	5.38	0.7417
2,000	6.07	5.25	10.96	6.33	0.0183 <sup>a</sup>	6.79	5.41	8.46	7.97	0.4868
3,000	4.29	4.32	9.04	8.49	0.0580	6.43	6.02	8.65	6.86	0.3147
4,000	4.29	3.85	12.50	10.61	0.0083 <sup>a</sup>	6.43	5.35	10.96	9.17	0.0982
6,000	13.21	6.96	21.54	14.41	0.0495 <sup>a</sup>	15.71	8.29	21.15	12.35	0.1487
8,000	10.00	6.79	18.85	15.51	0.0502	10.71	6.46	18.08	17.61	0.1411

Abbreviations: Avg, average;  $\sigma$ , standard deviation.

<sup>a</sup>Significant differences between the mean thresholds according to Student  $t$  test at a significance level of 0.05.

**Table 4** Thresholds at high frequencies among dentists with time in service of up to 10 years ( $n = 14$ ) and over 10 years ( $n = 26$ )

Frequency (Hz)	Right ear					Left ear				
	0–10 y		Over 10 y		$p$	0–10 y		Over 10 y		$p$
	Avg	$\sigma$	Avg	$\sigma$		Avg	$\sigma$	Avg	$\sigma$	
9,000	10.00	5.19	25.58	18.62	0.0041 <sup>a</sup>	12.50	7.78	23.27	15.74	0.0216 <sup>a</sup>
10,000	11.43	6.02	27.69	20.26	0.0059 <sup>a</sup>	12.14	7.52	27.50	20.46	0.0103 <sup>a</sup>
11,200	13.57	7.19	32.12	19.91	0.0018 <sup>a</sup>	12.14	5.08	33.08	21.45	0.0010 <sup>a</sup>
12,500	9.64	9.50	32.12	23.63	0.0016 <sup>a</sup>	8.21	7.23	36.73	24.33	0.0001 <sup>a</sup>
14,000	8.21	9.12	35.77	20.03	<0.0001 <sup>a</sup>	9.29	12.22	39.62	20.49	<0.0001 <sup>a</sup>
16,000	16.07	16.66	44.62	17.20	<0.0001 <sup>a</sup>	17.86	16.26	44.04	17.32	<0.0001 <sup>a</sup>

Abbreviations: Avg, average;  $\sigma$ , standard deviation.

<sup>a</sup>Significant differences between the mean thresholds according to Student *t* test at a significance level of 0.05.

## Discussion

In researching information on the effects of exposure to noise at work for dentists, it was observed that most had no training about noise in their formal education and 50% of the subjects knew the harmful effects of noise on health; however, only two dentists claimed to use hearing protection device even though they recognized that there was noise at work. Such findings corroborate another study in which 48 dentists, ages 22 to 55, participated, with only one reporting the use of hearing protection.<sup>23</sup>

In another study on the perception of noise from dentists, 49% of the 163 professionals surveyed felt that the noise in their workplace was of medium intensity. Only 3% knew the effects of noise on health and used hearing protection.<sup>10</sup>

Even with the presence of noise in the dentist's workplace, a lack of information is still dominant regarding the educational process for these professionals, and the lack of hearing health is shown in the low level of use of protection.

In the present study, we observed 6 (15%) cases of dentists with sensorineural hearing impairment. Other studies have found cases of hearing loss in dentists in various percentages. In a study conducted in the city of Cascavel, Paraná, with 85 dentists between 25 and 60 years of age and of both genders, 43.5% were found to have audiograms suggestive of NIHL.<sup>9</sup> In another study of 198 dentists in the state of Paraná, 27% had sensorineural hearing loss suggestive of NIHL.<sup>10</sup> Another study in Recife of 50 dental professionals of both genders aged between 25 and 54, and with work experience between 3 and 29 years, found 28 (56%) dentists had hearing loss.<sup>24</sup> In a study in the city of João Pessoa with 48 dentists, conventional audiometry was performed and 52.17% subjects had bilateral hearing loss, taking into account the frequencies of 3, 4, and 6 kHz.<sup>23</sup>

Dentists had lower mean hearing thresholds than the control group, and in the right ear, this difference was significant at frequencies of 500, 1,000, 6,000, and 8,000 Hz (► **Table 1**). A study with dentists in Bauru, Sao Paulo, also found the right ear to have worse hearing thresholds than the left ear.<sup>21</sup> Other studies identified dentists presenting worse

thresholds in their left ears.<sup>25,26</sup> In relation to the laterality of the hearing thresholds, an unexpected finding was that the dentists' group had worse hearing thresholds in the right ear, because both ears are exposed to the noise simultaneously. Future research needs to address this issue.

Even considering that hearing thresholds at high frequencies were higher than those at conventional frequencies, there was no difference between the groups. Studies analyzing high-frequency audiometry in dentists observed a predisposition to hearing impairment; however, in these studies control groups were not used as a comparison to dentists.<sup>9,21</sup>

After 10 years of working as a dentist, there were reduced hearing thresholds in conventional audiometry for the right ear at frequencies of 2,000, 4,000, and 6,000 Hz, configured as an acoustic notch characteristic of hearing loss due to exposure to high sound pressure levels. In dentists with over 10 years' experience, all high frequencies showed significant worsening. These findings corroborate research that found that older workers with a longer time of service are most vulnerable to hearing impairment.<sup>9,27</sup> It is noteworthy that the age factor may also affect the results, especially in high-frequency hearing thresholds, because those with longer service as a dentist are also older.<sup>23,28</sup>

## Conclusion

This study showed that dentists are at risk for the development of sensorineural hearing loss, especially after 10 years of service. However, there were significant differences between the group of dentists and the control group (which was not exposed to occupational noise) only at frequencies of 500 Hz in both ears and 1,000, 6,000 and 8,000 Hz in the right ear. Even with the average hearing thresholds at high frequencies being worse than in conventional frequencies, there were no significant differences between groups.

We suggest further studies to compare groups exposed to and not exposed to occupational noise to better understand the pattern of hearing damage.

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