Clin Oral Invest (2006) 10: 8–16
DOI 10.1007/s00784-005-0003-6

ORIGINAL ARTICLE

Frieda Gijbels · Reinhilde Jacobs · Katrijn Princen · Olivia Nackaerts · Frans Debruyne

Potential occupational health problems for dentists in Flanders, Belgium

Received: 23 December 2004 / Accepted: 7 June 2005 / Published online: 22 September 2005

Abstract The aim of this study was to gather data on occupational health effects among Flemish dentists. A questionnaire on various potential health effects was sent out to randomly selected Flemish dentists. Pilot experimental studies were performed on hearing and sensory function of the fingers on small groups of dentists. Audiometric data of both ears, gathered with an interval of 10 years, were analysed. Sensory tests of the fingers were performed for dominant and non-dominant hands in relation to exposure time to (ultra)sonic equipment. Positive responses for the questionnaire were as follows: low back pain, 54% (stress-correlated); vision problems, 52.3% (age-correlated); infections, 9%; allergies, 22.5% (mainly latex); stress level was scored 7 on a scale from 0 to 10; diminished sensitivity of the fingertips, 6% and auditory disorders, 19.6%. Pilot audiometric data showed a hearing loss at 4,000 Hz for the left ear, presumably indicative of occupational noise trauma. The two-point discrimination ability of the dominant hand tended to diminish in line with the number of years of practice. Dentists in Flanders were found to suffer from various health-related problems. More elaborate studies are required to provide more details on the risks for occupational hearing impairment and vibration hand neuropathy and to determine whether the problems described were related to the practice of dentistry.

Keywords Questionnaire · Dental · Health · Occupation

F. Gijbels · R. Jacobs · K. Princen · O. Nackaerts
Oral Imaging Centre, School of Dentistry,
Oral Pathology and Maxillofacial Surgery,
Faculty of Medicine,
Katholieke Universiteit Leuven,
Leuven, Belgium

F. Debruyne
Department of Otorhinolaryngology,
Faculty of Medicine,
Katholieke Universiteit Leuven,
Leuven, Belgium

R. Jacobs (✉)
Kapucijnenvoer 7,
B-3000 Leuven, Belgium
e-mail: Reinhilde.jacobs@med.kuleuven.be
Tel.: +32-16-332410
Fax: +32-16-332410

Introduction

The dental practitioner is confronted with a number of possible occupational threats to his general health on a daily basis. Besides the potential risks of scattered radiation deriving from diagnostic exposure of patients (Gijbels et al., unpublished data), there are numerous other occupational health risks. The literature on musculoskeletal problems, neurovascular disorders, sight and hearing complaints, infections, allergies, psychological stress, kidney disease and disturbances in short-term memory among dentists will be summarized. Musculoskeletal problems seem to occur more amongst dentists [3, 31, 54]. They often result from a prolonged forced working position of the dentist, allowing good sight in the narrow work area of the patient's mouth. This could lead to increased disk pressure and spinal hypomobility and thus low back pain and muscle ischaemia [57]. Abduction or flexion of the upper arm and flexion and rotation of the neck [19, 20, 39] can cause injuries of the neck and shoulder region. Repetitive movements of arms and hands, as often performed in dentistry, are known risk factors for musculoskeletal disorders [38]. Female dentists are reported to have more musculoskeletal complaints than their male colleagues [17, 19, 31, 37, 52]. Younger dentists would have more musculoskeletal disorders than older dentists [19, 37, 52]. Furthermore, dentists reporting psychological stress would have more musculoskeletal complaints [17, 34, 52].

The dental profession is often perceived as rather stressful, and a number of studies pay attention to psychological stress and stress-related health problems in the dental population. A strict time schedule, coping with anxious patients or painful treatments are frequently referred to as major stressors [40, 42, 59]. In the long term, these high

levels of stress could lead to burnout, with typical characteristics of emotional exhaustion, depersonalisation and reduced personal accomplishment [23, 30, 45]. Blood pressure and heart rate are shown to be significantly higher during work than during other activities, whereas these differences could not be observed in a non-dentist population [24]. Kidney disease and memory disturbances are reported to have a higher prevalence within a dentist population. An association with urinary mercury levels could, however, not be proven [49, 50].

A well-known occupational risk for dentists concerns irritations or allergic reactions towards different dental materials and products. The use of latex examination gloves during dental treatment has induced a shift in the type of occupational irritations and allergies. Whereas irritations and allergies were previously mainly caused by restorative or prosthodontic materials, they derive in recent years mainly from latex proteins and other rubber glove chemicals, from methacrylates which have the capacity to penetrate gloves and from disinfectants [27, 51]. Most adverse reactions against dental materials are type 1 (IgE-mediated) or type 4 (T-cell mediated, delayed) allergies. Latex allergies among dental professionals are well documented: 23% of Swedish dentists report latex glove intolerance, which appears to be latex allergy in 11% [60]. In a UK study, 18.5% of dental students and 22.8% of dental practitioners report adverse skin reactions to latex gloves [5]. Furthermore, hand dermatoses would occur more often among women and atopic subjects [31].

Dentistry could also lead to a number of vision-related problems. Mechanical injuries can be caused by particles of human tissues or restorative materials released during drilling or scaling [56]. Fatigue of the eyes can result from prolonged and concentrated working days [56]. UV light used in laser therapy is hazardous to the eye and can cause cataract [8, 56]. Blue light from light-curing units is also harmful to the eye [53]. Presbyopia increases in the general population with age and thus also in the dental population. For a profession where adequate vision is indispensable, it is striking, however, that 27% of practising dentists fails a near-vision test at a working distance of 25 cm, the vast majority of these practitioners being 45 years of age or more [12].

Another risk relates to different kinds of bacteria, viruses, prions and fungi, which may cause occupational infection of the dentist. The emergence of blood-borne pathogens like HIV, HBV and HCV has urged dentists to adopt a number of precautions that have become generally accepted [6, 16]. Needle-stick injuries should be treated immediately [55]. Bacterial aerosols are induced by the use of high-speed drills or (ultrasonic) scaling and possibly through air conditioning and ventilation systems [32].

Noise is inevitably associated with the use of certain dental equipment. Especially high-speed drills and ultrasonic scalers could lead to hearing loss among dentists [7]. In the audible range, the limit for possible hearing damage would be at 70–85 dB. In the ultrasonic range (>20 kHz), the limit would be 110 dB. Dental turbines can yield noise of 32 kHz and 110 dB, which implies potential auditory risks [7]. Hearing loss among dentists is a matter of debate. In a study by Zubick et al. [61], dentists show a greater hearing loss at 4 kHz compared to controls. The hearing loss is greater at the left side for right-handed dentists. In another study on dentists, hearing loss is found at 4, 6 and 8 kHz, which is greater than the expected loss for a general population [33]. Other studies reveal no significant hearing disorders among dentists or report sound levels too low to cause damage [21, 46, 58].

Sensory disturbances of the hands and fingers can be related to neurological or vascular disorders. The hand-arm vibration syndrome is reported in occupations where vibrating machinery is used, such as stone-cutting [43] and chain-saw use in forestry work [10]. It is characterised by paraesthesia of the fingers, pain or tenderness in the wrist or hand, whitening of finger(s) and muscle weakness [22] and is often accompanied by carpal tunnel syndrome.

Among dentists, carpal tunnel syndrome [26], numbness and paraesthesia and Raynaud's phenomenon [38] are reported.

For the sensory disturbances of the hand caused by nerve injury, a distinction should be made between damage to large myelinated nerve fibres (e.g. carpal tunnel syndrome) and small nerve fibre injury of the fingertips, resulting in numbness and paraesthesia [41]. While nerve compression syndromes, such as carpal tunnel syndrome, are probably related to forced working positions and repetitive movements [13–15, 26], small nerve fibre injury would be caused by vibration (drill, ultrasonic scaler) [41]. While nerve compression can be revealed by median nerve tests, small nerve fibre disorders can be tested with sensory tests. Among these sensory tests, light-touch sensation (with Semmes–Weinstein monofilaments), two-point discrimination and thermal sensation are frequently used [29] to determine the activation threshold of the skin receptors.

All of the aforementioned experiences could possibly lead to working inability and even cessation of dental practice [11].

The present study was undertaken because, to date, no data are available on the work-related health status of Belgian dental practitioners. It is built up in two parts, with the first part being a questionnaire addressing different possible health problems. The second part concentrates on auditory function and sensory response of the fingers and consists of a number of pilot experiments on small groups of dentists.

Material and methods

Questionnaire

A written questionnaire (Appendix) was sent by mail or fax to a random sample (n=500) of dental practitioners in Flanders (Dutch-speaking part of Belgium). To avoid bias from regional differences, the questionnaires were equally distributed throughout Flanders. Non-respondents were contacted a second time by telephone in order to create a representative group.

Statistics were performed with Statistica 5.1 for Windows (StatSoft, Tulsa, OK, USA). The level of significance was set at $p<0.05$.

Pilot experimental studies

Auditory function

Hearing tests of a group of 13 first year dental students performed in 1993 were compared to new tests on the same group performed in 2003. All subjects were born in 1975. At the time of the second test, all students had graduated for 5 years. Six of them were general practitioners, three were prosthodontists, three were periodontologists and one was an endodontist. The tests were performed by the ENT department of the University Hospital. One of the subjects had a temporary cochlear disorder at the second test (2003), which was treated with medication before testing and was not work-related. Before performing auditory tests, the tympanic membrane of the subjects was inspected. Cerumen had to be removed in one subject before auditory tests were performed. Auditory tests were performed in an audiological room, and a tone audiogram was constructed for each test subject. Hearing performance (in dB HL) was tested at increasing frequencies ranging from 125 Hz to 18 kHz. For each frequency, the differences in hearing threshold between the first (1993) and the second (2003) test were calculated. Left and right ear were compared with Wilcoxon matched-pairs tests.

Sensory function of fingers

Sensory tests were performed on the dominant and non-dominant hands of a group of 20 randomly selected dentists (ten female). The non-dominant hand was considered as the control, as this hand was assumed not to be subject to vibrations deriving from handpieces or (ultra) sonic scalers. The group of dentists was split in four subgroups depending on the number of years of practice. The first subgroup (1 to 9 years of practice) consisted of four practitioners, the second (10–19 years practice) of four practitioners, the third (20–29 years practice) of nine practitioners and the fourth subgroup (≥30 years of practice) of three practitioners. Three sensory tests were performed on both hands for each dentist in the same order. Whereas two-point discrimination and light-touch sensation tests investigate mechanoreceptor function, thermal sensation tests can reveal thermoreceptor dysfunction.

a. Two-point discrimination test—This test was originally developed for testing nerve repair after surgery (The Clinical Assessment Committee of the American Society for Surgery) [35]. The testing device [29] consists of a constant force periodontal probe, on which small plastic testing discs with two wires can be attached (Fig. 1). A total number of 15 discs was used, with increasing distances between pins (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18 and 20 mm). Care was taken that the two pins touched the skin simultaneously and that the pressure was sustained for at least 2 s. The subject was blinded and was told that one or two pins were brought into contact with the skin. He had to report whether he felt one or two pressure points. The test was performed as a "staircase" method: first, the disk with the largest distance between the pins was used. When a positive result was recorded, the next disk (with a smaller distance between pins) was used, and the procedure was continued with narrowing pin-distance until the subject only felt one pressure point. Then the test was repeated, starting with a disk with larger pin distance until the detection limit was determined. In between, "blanco" tests were performed, with only one pin touching the skin, in order to check the reliability of the answers.

Fig. 1 Constant pressure probe with disk with two pins, used for the two-point discrimination test of the skin

b. Thermal sensory test—Four disks of different materials [copper, steel, glass, polyvinyl chloride (PVC)] were mounted on the constant pressure probe and applied to the skin of the fingertips. Because of the different thermal conductivity of the materials, a different thermal sensation will be provoked. Because of the good thermal conductivity of copper, this disk will be experienced as the coldest, followed by steel, then glass, and finally, the PVC disk will be experienced as the least cold. For the test, two materials were offered each time to the subject, who had to decide whether the second material was colder or not. A correct answer was recorded as "+", a wrong answer as "–". Afterwards, the "correct" ratio was calculated.
c. Light-touch sensation test—For the third test, the Semmes–Weinstein Aesthesiometer (Stoelting, IL, USA) [9] (Fig. 2) was used to measure the sensitivity of the fingertips. A set of these nylon monofilament probes, with decreasing filament thickness, was applied to the skin until they bended. The subjects had to close their eyes and tell whether they felt pressure or not. Similar to the two-point discrimination test, the staircase method was used to determine the detection threshold.

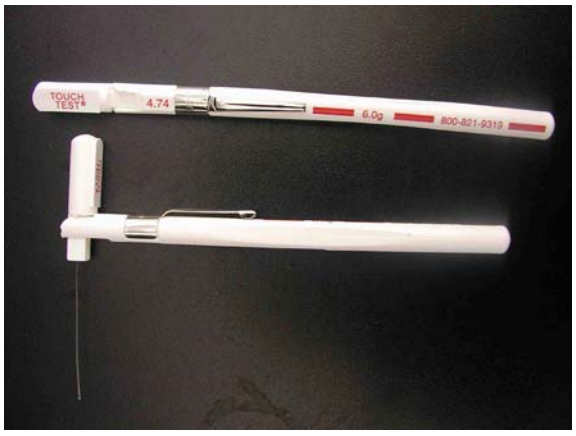


Fig. 2 Semmes–Weinstein monofilaments are clinically used to measure light-touch sensitivity of the fingertips

Data and statistical analysis of the pilot tests

Statistics were performed with Statistica 5.1 for Windows (StatSoft). The level of significance was set at $p<0.05$. For auditory testing, descriptive and non-parametric statistics were performed. For sensory testing of the different age groups, analysis was limited to descriptive statistics only. The limited number of subjects in each age subgroup and the known inter-subject variability amongst sensory testing prevented further statistical analysis [29].

Results

Questionnaire

Characteristics of respondents

Three hundred and eighty-eight (out of 500) forms were returned and analysed (response rate of 78%). A total of 55.7% of the respondents were male. General practitioners constituted 83% of the respondents, and 46.6% were between 40 and 49 years of age (Fig. 3).

Table 1 Incidence of occupational health problems among dentists

Reported disorder	Positive responses in the survey (%)
Low back pain	54
Orthopaedic disorders	11
Vision problems	52.3
Occupational infections	9
Allergies	22.5
Diminished sensitivity of the fingers	6
Auditory disorders	19.6

Reported disorders

The reported disorders are summarized in Table 1. More than half (54%) of the respondents reported low back pain, while 11% mentioned orthopaedic disorders. Low back pain was significantly correlated with level of stress (Sign test, Wilcoxon matched-pairs test). About half of the dentists (52.3%) had vision-related problems, with a positive family history in 27%. Age and vision problems were significantly correlated [Sign test, Wilcoxon matched pairs test, Spearman test ($R=-0.223$)]. Nine per cent of the respondents reported to have had serious infections in the professional environment (5.1% viral, 3.9% bacterial). Allergies were reported by 22.5% of the respondents. About half of the allergies towards dental materials were latex allergy (48%), followed by nickel (19.5%), acrylates (13.8%) and polymers (11.5%). The median score on the stress rating scale was 7, with most scores between 5 and 8. Six per cent of the respondents reported diminished sensitivity of the fingers (52% male). According to the information obtained from the respondents, this did not seem to correlate with the duration of drilling/(ultra)sonic scaling. More than half of the dentists (55%) reported use of handpiece/(ultra)sonic scaler of more than 10 h per week. Out of all the respondents, 19.6% reported auditory disorders and 5.4% mentioned a family history of comparable disorders. Auditory disorders were significantly correlated with age (Kruskal–Wallis ANOVA).

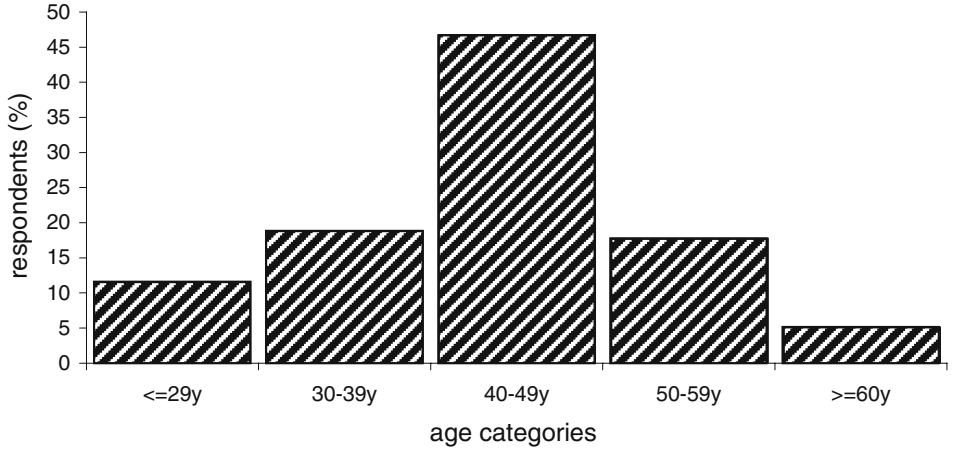


Fig. 3 Diagram showing age distribution of respondents

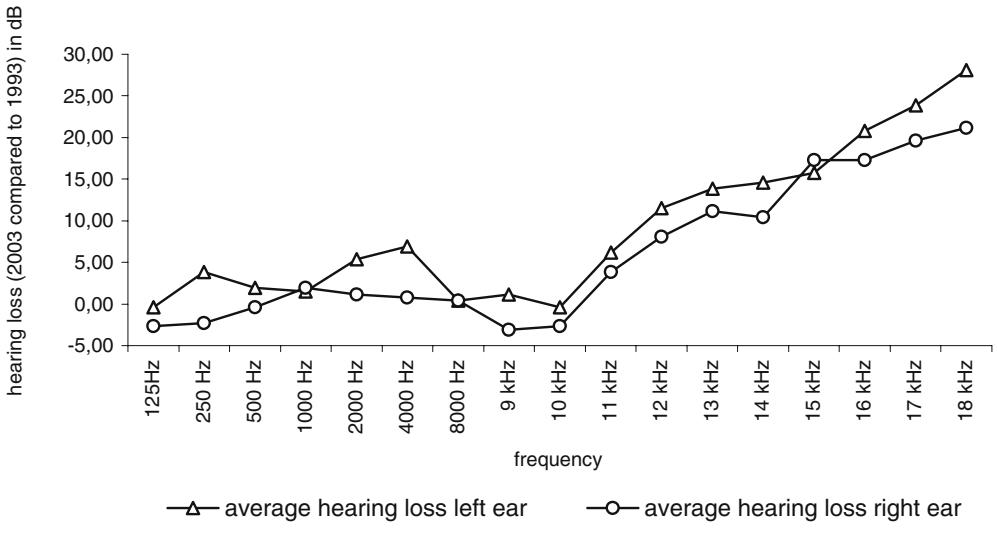


Fig. 4 Differences in audiogram data of 1993 and 2003

Pilot experimental studies

Auditory function

When the differences in audiogram data of 1993 and 2003 were compared (Fig. 4), the difference in hearing performance varies between +5 and −5 dB HL, which can be considered as a threshold. The only exception is found for the left ear at 4,000 Hz. At higher frequencies (starting from 12 kHz), a clear hearing loss can be observed, which is increasing in line with the frequency (±10 dB at 12 kHz, ±25 kHz at 18 kHz). When hearing loss of left and right ear were compared (Wilcoxon matched-pairs test), significant differences were found for 250 Hz (difference 8.46 dB) and 4,000 Hz (difference 6.15 dB), where the left ear performed worst. The difference between left and right ear remained significant for the individual data at 4000 Hz, which could be indicative for noise trauma.

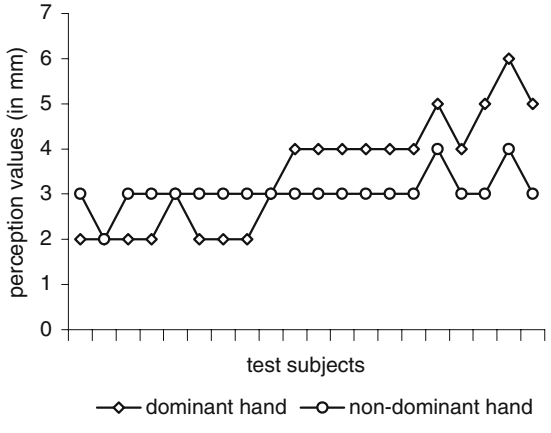


Fig. 5 The perception values (in millimetre) for the different subjects, both for dominant and non-dominant hands

Sensory function of fingers

Following are the results of the different sensory tests:

a. Two-point discrimination test—For the non-dominant hand, the detection limit for two-point discrimination was 3 mm. For the dominant hand, the detection limit was 2 mm for the first two cohorts (1–19 years practice). For the third cohort (20–29 years practice) it raised to 3 mm, and for the fourth cohort (≥30 years practice) it reached 5 mm (Fig. 5).
b. Thermal sensory test
c. Monofilament test—For both the thermal and monofilament tests, differences between hands or years of practice could not be demonstrated.

Discussion

The total number of dentists in Flanders is about 4,200. In order to create a representative sample of dentists, initial non-respondents were contacted a second time by telephone. Still, 112 out of 500 dentists preferred not to respond, which may cause a non-response bias. When contacted by telephone, the main reason for non-response appeared to be lack of time. All respondents were practicing dentists, which may cause bias because dentists retired for health reasons are not included.

More than half of the respondents (54%) mentioned low back pain, which will be mainly caused by bending of the back to allow good sight, causing (over)stretching of muscles and ligaments of the spine. Mainly the muscle and ligament fibres of the musculus latissimus dorsi at the level of the lumbal and sacral spine are overloaded by bending the thorax forward [54], causing low back complaints. The prevalence of low back pain is comparable to other studies on dentists [19, 37, 47]. The positive cor-

relation with stress, as found in the present study, has also been mentioned previously [34, 52].

Orthopaedic complaints were reported by 11% of the dentists. Although not specified in the present study, these complaints will probably be mainly related to overloading of shoulders, cervix and arm, as reported in previous studies [19, 20, 47]. In the present study, it was not analysed whether magnification was used during work and whether this would influence the prevalence of low back pain or orthopaedic complaints.

The median score on the stress rating scale of 7 indicates that the dental profession is perceived as highly stressful. This is also in accordance with previously published data [40, 42, 59].

Impaired vision was reported by 52.3% of the respondents. As in the general population, there was a correlation between age and vision problems [1, 2, 28]. Because of the high visual demands of the dental profession and the close working distance (between 25 and 40 cm) of the dentist, correction of visual impairment is of great importance [12].

According to the respondents, the prevalence of occupational infections was 9% (5% viral infections, 4% bacterial). This number seems to be relatively high because appropriate measures can be taken in order to avoid contamination. It was not the aim of the study to further specify the type of infection.

About one out of four (22.5%) of the dentists reported allergies. About half of these allergies were towards latex. It was, however, beyond the scope of the current study to investigate whether the reported allergic reactions were true allergies or rather latex intolerances.

Although diminished sensitivity of the fingers was reported by only a small number of dentists (6%), our pilot sensory experiments on a small number of dentists showed a tendency towards diminishing two-point discrimination for the dominant hand according to years of dental practice. For the most recently graduated dentists, the dominant hand performed better than the other hand, but the decreasing discrimination ability with increasing time after graduation might be indicative for some vibration neuropathic changes. Regarding light-touch sensation and thermal sensory tests, no differences were found. Additional studies are however necessary to explore these data among larger groups of practitioners, allowing the use of elaborate statistical analysis. Ekenvall et al. [18] found a difference in sensitivity of the fingers in a group of long-term exposure to vibration compared to a group of short-term vibration exposure. In the latter study, however, the sensitivity was disturbed in both exposed and non-exposed fingers of the dominant hand, which suggests an indirect effect of vibration to the fingers.

One out of five (19.6%) respondents mentioned auditory disorders, which showed a significant positive correlation with age. Age-related hearing loss is a common phenomenon among the general population and starts with hearing loss at higher frequencies [7]. In previous studies [48, 61], hearing loss among dentists appeared to be higher than among a control group in the high-frequency range (4,000 and 6,000 Hz). According to other studies, dentists would not be at higher risk for hearing loss than a control group [21, 46], or the equipment used produced noises that are harmless for hearing [36, 44, 58]. The latter is countered by another study, where potentially damaging frequencies were found for dental air turbines [4].

Our pilot hearing experiments showed a striking hearing loss at 4,000 Hz for the left ear, which is in accordance with a previous study [61] where a control group of physicians was used. The reason for greater hearing loss of the left ear could possibly be explained by the shorter distance of this ear towards the rotating/vibrating equipment for right-handed practitioners (all test subjects were right-handed) [61]. This hearing loss at 4,000 Hz is superimposed on an overall age-related hearing loss at higher frequencies [61].

The results of the present study should be interpreted in the light of the health data of the general population. A national health survey by the Belgian government (Wetenschappelijk Instituut Volksgezondheid, Gezondheidsenquête, http://www.aps.vlaanderen.be/sgml/reeksen/3571.htm) shows that in a general population with higher education, 24% reports one disease and 18% reports two or more diseases. This is a total of 42% with one or more diseases. It is not clear whether allergies, vision and hearing are included in these figures. The prevalence of low back pain in a sample of the general Belgian population is 41.8% [25], which is lower than in our dentists' sample (54%).

Further studies are, however needed to clear out whether the afore-mentioned health issues are related to the practice of dentistry.

Conclusions

From the questionnaire data, it can be concluded that various health problems occur among dentists. Low back pain and impaired vision are reported by more than half of the dentists, whereas allergies and auditory disorders are mentioned by about one out of five respondents. General orthopaedic disorders, occupational infections and diminished finger sensitivity are stated by 6 to 11%. Stress level is rated 7 on a scale from 0 to 10.

Pilot follow-up data on auditory performance over a 10-year period indicate pronounced hearing loss at 4,000 Hz for the left ear. Sensory tests of the fingertips indicate a tendency for a diminishing two-point discrimination ability of the dominant hand in line with the number of years of practice. Light-touch sensation and thermal sensation do not show any differences. Further studies should clarify whether the various health effects can be explained by the practice of dentistry.

Appendix

OCCUPATIONAL HEALTH PROBLEMS AMONG DENTISTS

QUESTIONNAIRE

1. Gender ☐ male ☐ female

2. Age ☐ ≤ 29 y ☐ 30-39 y ☐ 40-49 y ☐ 50-59 y ☐ ≥ 60 y

3. Time since graduation ☐ < 10 y ☐ 10-25 y ☐ > 25 y

4. Working as ☐ general practitioner ☐ specialist

5. If you have (had) any of the health disorders mentioned below, please tick the appropriate box(es)

   ☐ cardiovascular disorders ☐ allergie(s)
   ☐ lung disorders ☐ neurological disorders
   ☐ kidney disorders ☐ haematological disorders
   ☐ endocrine disorders ☐ virological infections
   ☐ rheumatological disorders ☐ orthopedic complaints
   ☐ other: ……

6. Do you have auditory complaints? ☐ yes ☐ no
   If yes, is there a positive family history of comparable complaints?
   ☐ *yes* ☐ *no*

7. Do you have an impaired vision? ☐ yes ☐ no
   If yes, is there a positive family history of comparable complaints?
   ☐ *yes* ☐ *no*

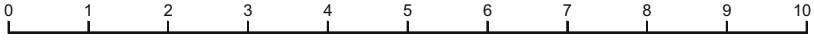
8. Do you have diminished tactile function of the fingers? ☐ yes ☐ no

9. Do you have low back pain? ☐ yes ☐ no

10. Did you ever get a serious infection in your office? ☐ yes ☐ no
    If yes, please specify: ☐ *viral* ☐ *bacterial* ☐ *other*

11. Are you allergic to dental materials/products? ☐ yes ☐ no
    If yes, please specify product(s)/material(s): ……
    ……

12. Please indicate on the scale below the level of stress in your working environment
    (0 = no stress; 10 = unbearable stress)



13. How many hours per week are you exposed to rotating or vibrating dental equipment?
    ☐ < 2 h ☐ 2-10 h ☐ > 10 h

References

1. Abrahamson IA Jr (1984) Eye changes after forty. Am Fam Phys 29:171–181
2. Adler-Grinberg D (1986) Questioning our classical understanding of accommodation and presbyopia. Am J Optom Physiol Opt 63:571–580
3. Åkesson I, Schutz A, Horstmann V, Skerfving S, Moritz U (2000) Musculoskeletal symptoms among dental personnel—lack of association with mercury and selenium status, overweight and smoking. Swed Dent J 24:23–28
4. Altinoz HC, Gokbudak R, Bayraktar A, Belli S (2001) A pilot study of measurement of the frequency of sounds emitted by high-speed dental air turbines. J Oral Sci 43:189–192
5. Amin A, Palenik CJ, Cheung SW, Burke FJ (1998) Latex exposure and allergy: a survey of general dental practitioners and dental students. Int Dent J 48:77–83
6. Araujo MW, Andreana S (2002) Risk and prevention of transmission of infectious disease in dentistry. Quintessence Int 33:376–382
7. Barek S, Adam O, Motsch JF (1999) Large band spectral analysis and harmful effects of dental turbines. Clin Oral Investig 3:49–54
8. Barkana Y, Belkin M (2000) Laser eye injuries. Surv Ophthalmol 44:459–478
9. Bell-Krotoski JA, Fess EE, Figarola JH, Hiltz D (1995) Threshold detection and Semmes–Weinstein monofilaments. J Hand Ther 8:155–162

10. Bovenzi M, Giannini F, Rossi S (2000) Vibration-induced multifocal neuropathy in forestry workers: electrophysical findings in relation to vibration exposure and finger circulation. Int Arch Occup Environ Health 73:519–527
11. Burke FJ, Main JR, Freeman R (1997) The practice of dentistry: an assessment of reasons for premature retirement. Br Dent J 182:250–254
12. Burton JF, Bridgman GF (1990) Presbyopia and the dentist: the effect of age on clinical vision. Int Dent J 40:303–312
13. Cederlund R, Isacsson A, Lundborg G (1999) Hand function in workers with hand-arm vibration syndrome. J Hand Ther 12: 16–24
14. Cherniack MG, Moalli D, Viscolli C (1996) A comparison of traditional electrodiagnostic studies, electroneurometry, and vibrometry in the diagnosis of carpal tunnel syndrome. J Hand Surg 21:122–131
15. Conrad JC, Osborn JB, Conrad KJ, Jetzer TC (1990) Peripheral nerve dysfunction in practicing dental hygienists. J Dent Hyg 64:382–387
16. De Paola LG (2003) Managing the care of patients infected with bloodborne diseases. J Am Dent Assoc 134:350–358
17. Ekberg K, Bjørkqvist B, Malm P, Bjerre-Kiely B, Karlsson M, Axelson O (1994) Case-control study of risk factors for disease in the neck and shoulder area. Occup Environ Med 51:262–266
18. Ekenvall L, Nilsson BY, Falconer C (1990) Sensory perception in the hands of dentists. Scand J Work, Environ & Health 16:334–339
19. Finsen L, Christensen H, Bakke M (1998) Musculoskeletal disorders among dentists and variation in dental work. Appl Ergon 29:119–125
20. Finsen L, Christensen H (1998) A biomechanical study of occupational loads in the shoulder and elbow in dentistry. Clin Biomech 13:272–279
21. Forman-Franco B, Abramson AL, Stein T (1978) High-speed drill noise and hearing: audiometric survey of 70 dentists. J Am Dent Assoc 97:479–482
22. Friden J (2001) Vibration damage to the hand: clinical presentation, prognosis and length and severity of vibration required. J Hand Surg 26:471–474
23. Gorter RC, Albrecht G, Hoogstraten J, Eijkman MA (1999) Professional burnout among Dutch dentists. Community Dent Oral Epidemiol 27:109–116
24. Gortzak RA, Stegeman A, Ten Brinke R, Peters G, Abraham-Inpijn L (1995) Ambulant 24-hour blood pressure and heart rate of dentists. Am J Dent 8:242–244
25. Goubert L, Crombez G, De Bourdeaudhuij I (2004) Low back pain, disability and back pain myths in a community sample: prevalence and interrelationships. Eur J Pain 8:385–394
26. Hamann C, Werner RA, Franzblau A, Rodgers PA, Siew C, Gruninger S (2001) Prevalence of carpal tunnel syndrome and median neuropathy among dentists. J Am Dent Assoc 132:163–170
27. Hamann CP, Rodgers PA, Sullivan KM (2004) Occupational allergens in dentistry. Curr Opin Allergy Clin Immunol 4:403–409
28. Haronian E, Wheeler NC, Lee DA (1993) Prevalence of eye disorders among the elderly in Los Angeles. Arch Gerontol Geriatr 17:25–36
29. Jacobs R, Wu C-H, Goossens K, Van Loven K, Van Hees J, Van Steenberghe D (2002) Oral mucosal versus cutaneous sensory testing: a review of the literature. J Oral Rehabil 29:923–950
30. Kaney S (1999) Practice management forum. Sources of stress for orthodontic practitioners. Br J Orthod 26:75–76
31. Kerosuo E, Kerosuo H, Kanerva L (2000) Self-reported health complaints among general dental practitioners, orthodontists and office employees. Acta Odontol Scand 58:207–212
32. Leggat PA, Kedjarune U (2001) Bacterial aerosols in the dental clinic: a review. Int Dent J 51:39–44
33. Lehto TU, Laurikainen ET, Aitasalo KJ, Pietila TJ, Helenius HY, Johansson R (1989) Hearing of dentists in the long run: a 15-year follow-up study. Community Dent Oral Epidemiol 17: 207–211
34. Lehto TU, Helenius HY, Alaranta HT (1991) Musculoskeletal symptoms of dentists assessed by a multidisciplinary approach. Community Dent Oral Epidemiol 19:38–44
35. Mackinnon SE, Dellon AL (1985) Two-point discrimination tester. J Hand Surg 10:906
36. Man A, Neuman H, Assif D (1982) Effect of dental drill noise on dentists' hearing. Isr J Med Sci 18:475–477
37. Marshall ED, Duncombe LM, Robinson RQ, Kilbreath SL (1997) Musculoskeletal symptoms in New South Wales dentists. Aust Dent J 42:240–246
38. Milerad E, Ekenvall L (1990) Symptoms of the neck and upper extremities in dentists. Scand J Work, Environ & Health 16:129–134
39. Milerad E, Ericson MO, Nisell R, Kilbom A (1991) An electromyographic study of dental work. Ergonomics 34:953–962
40. Moore R, Brødsgaard I (2001) Dentist's perceived stress and its relation to perceptions about anxious patients. Community Dent Oral Epidemiol 29:73–80
41. Morse TF, Michalak-Turcotte C, Atwood-Sanders M, Warren N, Peterson DR, Bruneau H, Cherniack M (2003) A pilot study of hand and arm musculoskeletal disorders in dental hygiene students. J Dent Hyg 77:173–179
42. Myers HL, Myers LB (2004) "It's difficult being a dentist": stress and health in the general dental practitioner. Br Dent J 197:89–93
43. Noël B (2000) Pathophysiology and classification of the vibration white finger. Int Arch Occup Environ Health 73:150–155
44. Praml GJ, Sonnabend E (1980) Noise-induced hearing loss caused by dental turbines. Dtsch Zahnarztl Z 35:400–406
45. Rada RE, Johnson-Leong C (2004) Stress, burnout, anxiety and depression among dentists. J Am Dent Assoc 135:788–794
46. Rahko AA, Karma PH, Rahko KT, Kataja MJ (1988) High-frequency hearing of dental personnel. Community Dent Oral Epidemiol 16:268–270
47. Ratzon NZ, Yaros T, Mizlik A, Kanner T (2000) Musculoskeletal symptoms among dentists in relation to work posture. Work 15:153–158
48. Reitemeier B, Fritsche F (1990) The long-term effects of noise on dentists. Zahn-Mund-Kieferheilkd Zentbl 78:735–738
49. Ritchie KA, Gilmour WH, Macdonald EB, Burke FJT, McGowan DA, Dale IM, Hammersley R, Hamilton RM, Binnie V, Collington D (2002) Health and neuropsychological functioning of dentists exposed to mercury. Occup Environ Med 59:287–293
50. Ritchie KA, Burke FJT, Gilmour WH, Macdonald EB, Dale IM, Hamilton RM, McGowan DA, Binnie V, Collington D, Hammersley R (2004) Mercury vapour levels in dental practices and body mercury levels of dentists and controls. Br Dent J 197:625–632
51. Rubel DM, Watchorn RB (2000) Allergic contact dermatitis in dentistry. Australas J Dermatol 41:63–69
52. Rundcrantz BL (1991) Pain and discomfort in the musculoskeletal system among dentists. Swed Dent J, Suppl 76:1–102
53. Satrom KD, Morris MA, Crigger LP (1987) Potential retinal hazards of visible-light photopolymerization units. J Dent Res 66:731–736
54. Shugars D, Miller D, Williams D, Fishburne C, Strickland D (1987) Musculoskeletal pain among general dentists. Gen Dent 35:272–276
55. Smith AJ, Cameron SO, Bagg J, Kennedy D (2001) Management of needlestick injuries in general dental practice. Br Dent J 190:645–650
56. Szymanska J (2000) Work-related vision hazards in the dental office. Ann Agric Environ Med 7:1–4

57. Valachi B, Valachi K (2004) Mechanisms leading to musculoskeletal disorders in dentistry. J Am Dent Assoc 134:1344–1350
58. Wilson CE, Vaidyanathan TK, Cinotti WR, Cohen SM, Wang SJ (1990) Hearing-damage risk and communication interference in dental practice. J Dent Res 69:489–493
59. Wilson RF, Coward PY, Capewell J, Laidler TL, Rigby AC, Shaw TJ (1998) Perceived sources of occupational stress in general dental practitioners. Br Dent J 23:499–502
60. Wrangsjö K, Wallenhammar LM, Ortengren U, Barregard L, Andreasson H, Björkner B, Karlsson S, Meding B (2001) Protective gloves in Swedish dentistry: use and side-effects. Br J Dermatol 145:32–37
61. Zubick HH, Tolentino AT, Boffa J (1980) Hearing loss and the high speed dental handpiece. Am J Public Health 70:633–635