Respiratory morbidity in a population of French dental technicians

S Radi, J C Dalphin, P Manzoni, D Pernet, M P Leboube, J F Viel

Occup Environ Med 2002;**59**:398–404

See end of article for authors' affiliations

Correspondence to:
Dr S Radi, Centre de
Médecine du Travail de
l'Artisanat de la
Haute-Garonne, 30 rue de
l'Etoile, 31000 Toulouse,
France;
samiradi@aol.com

Accepted
12 February 2002

Aims: To compare wage earner dental technicians with non-exposed salaried subjects for the prevalence of respiratory symptoms and function, and chest x ray abnormalities.

Methods: A total of 134 dental technicians and 131 non-exposed subjects participated. A medical and an occupational questionnaire were filled in to evaluate the prevalence of respiratory symptoms and occupational exposures. Subjects underwent respiratory tests and chest x ray examination.

Results: Mean age of the dental technicians was 36.6 years with a mean duration of dental work of 16.5 years. There was a significant risk of cough (day and night) and usual phlegm in dental technicians. Respiratory function parameters were lower in dental technicians with a significant difference between exposed and non-exposed groups for % FVC (forced vital capacity), % FEF₂₅ (forced mid expiratory flow), and % FEF₅₀. The prevalence of small opacities increased with age. Small opacities were significantly related to an exposure to asbestos in the past.

Conclusions: Our young population of dental technicians is at risk of respiratory morbidity. They should benefit from adequate technical prevention measures.

Dental technicians are exposed to dust and vapour during the manufacture of dental prostheses from the negative impression of the patient's teeth obtained by the dentist. In the process, a positive mould is made of plaster. The process to manufacture fixed metal and ceramic prostheses is based on wax model casting. Here, a positive reproduction of the tooth is made of wax. This pattern is placed in a cylinder, which is filled in with refractory material. Heating eliminates the wax and the empty mould chamber is filled in with molten nickel–chromium alloy. After cooling, the mould is broken and the prostheses are polished with a sandblaster and hand finishing tools.¹ For ceramic prostheses, a ceramic layer is put on the alloy with a brush before firing. Resin prostheses do not need a wax model. The negative impression is filled in by methyl methacrylate resin and the prosthesis is hand finished. A framework made of chromium–cobalt alloy can be necessary for resin prosthesis. The main airborne contaminants during the production process are plaster, and the refractory material that contains a high percentage of silica, wax, chromium, nickel and cobalt alloys, ceramic, and resin. Beryllium is used with a variable percentage to improve the hardness of nickel–chromium alloys; most of the current nickel–chromium alloys are free of beryllium. The use of asbestos has been prohibited in France since 1997; it was previously used as an isolating film between the cylinder and the refractory material.

A number of investigations have been conducted to identify the different types of risk encountered in denture manufacturing workshops.^{2–6} The risk is associated with inadequate local exhaust and ventilation, essentially for the preparation of plaster and refractory material, wax modelling, fusion of alloys, sanding, and hand finishing.¹

In France, there are about 14 000 dental technicians working in 4500 dental laboratories.² Eighty per cent of prostheses are made in small laboratories with less than five employees. In small laboratories, dental technicians can be exposed to most of the airborne contaminants generated during the manufacture of the prostheses because they are able to do any task (except manufacturing ceramic prostheses, which needs on the job experience).

Many cases of pneumoconiosis caused by silica,^{7–11} heavy metals,^{12–14} or beryllium^{15–17} have been reported.^{18–20} In addition,

because of concomitant exposures, complex pneumoconioses have been described associating heavy metals and silica,^{21–23} cobalt and beryllium,²⁴ or beryllium and aluminium.²⁵ Whereas numerous cases of pneumoconiosis have been reported in dental technicians, there have been few epidemiological studies assessing their respiratory morbidity and their relation with the polluting occupational tasks.

A study was performed in Switzerland in 1977 by Lob and Hugonnaud among 24 dental technicians, following the radiological discovery of micronodular pulmonary infiltration in a 48 year old dental technician.²⁴ Only one dental technician had decreased lung function probably related to his occupational exposure. Chest x rays were classified independently by four readers as normal, suspect, or abnormal. Five x ray films were considered to be suspect, suggestive of hard metal (cobalt and beryllium) pneumoconiosis.

In Salt Lake City, Rom *et al* conducted a study among 178 dental technicians and 69 non-exposed controls.¹⁷ Eight technicians, with a mean duration of dental work of 28 years, were diagnosed as having a simple pneumoconiosis by chest radiograph, related to past silica exposure or exposure to non-precious metal alloy dust. Their pulmonary function was within the normal range. The prevalence of pneumoconiosis in technicians with 20 or more years exposure (16.7%) was significantly higher than those with less than 20 years exposure (1.4%). Mean values for percentage predicted forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁) were reduced among male non-smoker technicians compared to male non-smoker controls; there was also a reduction in spirometry with increasing work years. Respiratory symptoms, except irritation cases considered to be work related were not more common among dental technicians than among controls.

Silica, cobalt, and beryllium may be implicated in pneumoconiosis aetiology. Sulotto *et al* studied 68 dental technicians in

Abbreviations: ECSC, European Community for Steel and Coal; FEF, forced mid expiratory flow; FEV, forced expiratory volume; FVC, forced vital capacity; ILO, International Labour Office

Italy.¹⁸ Sixty six per cent of the 15 dental technicians manufacturing non-precious alloy prostheses had a pneumoconiosis according to the ILO classification; 22.6% of the 53 technicians manufacturing other types of prostheses had small opacities with a profusion equal to 1/0. There was no decrease in respiratory function even in case of radiological pneumoconiosis.

Sherson *et al* investigated 31 dental technicians and 30 control subjects in Denmark.²⁰ There were no significant differences between dental technicians or control subjects in the prevalence of chronic bronchitis or dyspnoea. All mean lung function values were within normal limits and lung function results did not differ significantly in the two groups. A prevalence of 12.9% for pneumoconiosis was found.

Selden *et al* conducted a study in Sweden among 37 dental technicians with at least five years exposure to dust from cobalt chromium molybdenum alloys.¹⁴ Lung function was significantly lower than expected for vital capacity and FEV₁; the reduction in lung function was more pronounced in smokers. A pneumoconiosis prevalence of 16.2% was found among dental technicians, whereas all radiographs from 21 reference subjects were assessed as normal. Lung function of the six cases with radiological pneumoconiosis was not significantly different from the rest of the study group.

In Crete, Froudarakis *et al* studied 51 dental technicians and 51 control subjects.²⁶ Dental technicians reported significantly more respiratory symptoms than controls. Mean lung function values of the dental technicians, even in those with pneumoconiosis, were not significantly different from controls. No significant changes in lung function parameters were associated with smoking or occupational contaminants. A total of five radiological films showed pneumoconiosis (9.8%), for a mean exposure of 18.6 years. Lung function of subjects with radiological evidence of pneumoconiosis was not significantly different from the rest of the group.

Tuengerthal *et al* reported a higher prevalence of pneumoconiosis (38.6% for a mean duration of exposure of 11 years, increasing to 93.5% for over 20 years of exposure), probably explained by the recruiting method of their study.²⁷ Their cases were selected from hospitalised dental technicians. Szadowski *et al* found three cases of pneumoconiosis in a group of 149 dental technicians.²⁸ This low prevalence (1.3%) could be explained by a recruiting bias as 77% of the subjects worked in laboratories with more than 11 technicians. These large laboratories probably have efficient technical prevention measures, and thus exposure to airborne contaminants is low.

Only one study has been conducted in France¹⁹: in 1993 Choudat *et al* studied a group of 102 self employed dental technicians and 68 control workers. A significant relation was observed between respiratory symptoms and smoking habits but the prevalence of respiratory symptoms was not higher among dental technicians than among control subjects, except for the occurrence of increased cough and phlegm. All mean values of lung function for dental technicians and controls were within normal limits, but significant decreases in all mean lung function values were found among smokers by comparison with non-smokers. A positive interaction between smoking and occupational exposure was observed. The prevalence of small opacities greater than 1/0 was 11.8%; there was a significant increase with duration of exposure. No studies have been conducted in wage earner dental technicians in France.

Our goal was to compare wage earner dental technicians with non-exposed salaried subjects for the prevalence of respiratory symptoms and function and chest x ray abnormalities. If a difference between wage earner exposed and non-exposed groups was found, we could then investigate whether the respiratory morbidity was linked with the duration of dental work and the type of exposure (plaster, silica, wax, resin, metal alloys, ceramic, asbestos, beryllium). If the responsibility for one type of exposure could be proved, we would be able to prioritise improvement of preventive measures.

METHODS

This cross sectional study was undertaken with the cooperation of the Regional Social Insurance of Bourgogne and Franche-Comté (France). It took place in 1999 and involved six provinces. The occupational physicians in charge of the dental prosthesis laboratories carried out the medical examinations.

Population

The target population consisted of 417 dental technicians of both sexes, aged 16–60 years, working in 114 prostheses laboratories.

One occupational physician in each province of Bourgogne and Franche-Comté was informed of the study and had the responsibility of informing his colleagues and inviting them to participate. Physicians who agreed to participate included all the laboratories they were caring for. The reasons given by occupational physicians who did not participate were either the absence of knowledge of the existence of the study or lack of time.

Finally, 42 managers of dental laboratories (36.8% of the total) were contacted by their occupational physicians and asked to participate. In accordance with the size of dental laboratories in France, the number of employees in each laboratory ranges from one to 25. Eighty one per cent of the laboratories had one to five employees and 19% had more than five employees (mean 3.2 employees). A total of 134 of the 181 dental technicians asked to participate responded favourably. The reasons for non-inclusion of the remaining 47 dental technicians were a change of physician during the study period for 31 subjects (65.9%) and refusal for five subjects (10.6%); 11 (23.4%) did not attend their annual medical examination during the study period.

Exposed and non-exposed groups were set up with a ratio of 1:1. A total of 131 non-exposed subjects were included. The criteria for inclusion of non-exposed subjects was either having not been exposed in the past or being currently exposed to occupational respiratory pollutants. A full time occupational physician cares for 3000 workers. Among them, about 1000–2000 are not exposed to occupational respiratory pollutants. Each physician participating in the study selected controls from this population of non-exposed workers. Each first salaried subject coming to the yearly medical examination after attendance of a dental technician participating in the study matched for age $\pm$ 5 years and sex was included. The population of controls included was composed mostly of office workers, salespersons, accountants, and secretaries. The refusal rate among controls was 14.3%. The reason for non-inclusion of controls was lack of time to undergo chest x ray examination.

The workers were individually asked by their occupational physician to participate in the study and informed of its objectives. Each subject agreeing to participate gave written informed consent.

In addition to the usual medical examination, each participant was asked to fill in a medical and detailed occupational questionnaire. Questionnaires could be filled in after the examination and forwarded by the subjects to their occupational physician. Spirometry and chest x ray examination were performed.

Two dental technicians refused to fill in the occupational questionnaire and seven non-exposed subjects did not return the questionnaire during the study period.

Six dental technicians and 10 non-exposed subjects did not have spirometry and 26 subjects in each group did not undergo chest x ray examination because of lack of time.

Questionnaires

The medical questionnaire was adapted from the long version of the European Community Respiratory Health Survey questionnaire.²⁹

“History of allergy” covered nasal allergies including hay fever, eczema, or any kind of skin allergy, or allergy to insect

stings or bites. "Self reported asthma" was defined by a positive answer to the question "Have you ever had asthma?". A positive answer to the question "Do you usually have phlegm during the day or night?" defined "usual phlegm". "Chronic bronchitis" was defined as cough and expectoration for three months of the year or more over at least two consecutive years. "Dyspnoea" was defined as shortness of breath when hurrying on the level or walking up a slight hill. "Non-smokers" were defined as those having smoked less than one cigarette a day for a year. "Current smokers" smoked more than one cigarette a day; ex-smokers had stopped smoking at least one month before the time at which they filled in the questionnaire.

Occupational health physicians prepared the occupational questionnaire focused on dental technicians in collaboration with engineers and technicians of the Regional Social Insurance and dental laboratories managers. Questions concerned the size of the laboratory (number of employees), type (independent dental laboratory or dental surgery), and tasks regularly performed (preparation of plaster, refractory material or resin, modelling of wax, melting of metal alloys, breaking the mould, sandblasting, hand finishing, polishing, and application of ceramic on metal alloys). For exposed and non-exposed groups, specific questions about immediate or delayed symptoms in relation to occupational tasks were added to the medical questionnaire (cough, shortness of breath, wheezing).

Respiratory function tests

Respiratory function tests were performed according to the recommendations of the American Thoracic Society.³⁰ Five different spirometers were used to measure forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), forced mid expiratory flow (FEF₂₅₋₇₅), maximal flow rates at 25%, 50%, and 75% of exhaled FVC (FEF₂₅, FEF₅₀, FEF₇₅) and peak flow rate. They were calibrated daily for atmospheric pressure, hygrometry, and temperature, and periodically with a syringe. The same spirometer was used for each pair of exposed and non-exposed participants. At least three good tracings were obtained. The best value was selected after correction to body temperature and ambient pressure (BTPS). The FEV₁:FVC ratio was calculated. Values were expressed as a percentage of the European Community for Steel and Coal (ECSC) reference values, calculated in relation to sex, age, and height.³¹

Chest x ray examination

The films were interpreted according to the International Labour Office (ILO) classification of radiographs of pneumoconiosis, revised in 1980 with a standardised code. For evaluation of small opacities profusion, the 12 point scale of ILO was used.³²

They were read in a blind fashion by a radiologist (PM) and a chest physician (DP). In case of discordance between the two readers, a second chest physician read the films (JCD) and a collegiate reading conclusion was given at the end.

Data analysis

Both groups were compared for respiratory symptoms and function and chest x ray findings. An analysis was conducted within the dental technicians group to look for a dose-response relation between duration of work in the job and respiratory morbidity.

Quantitative variables (age, pack years, and spirometric parameters) were expressed as mean (SD). Student's *t* test was used to compare two groups for quantitative variables (age, mean pack years). A multiple linear regression was used to correlate respiratory function, exposure (the fact of being a dental technician), sex, smoking considered in two classes (current and ex-smokers versus non-smokers), and exposure to asbestos in two classes (having been exposed or not). A χ^2 test was used to compare two groups for qualitative variables (sex and smoking habits in two classes). A logistic regression

model was used to quantify the effect of exposure (being a dental technician or not, having been exposed to asbestos in the past), smoking considered in two classes, sex, and age on respiratory symptoms and on radiographic signs (expressed as present or absent). Risk was expressed by the odds ratio (equal to the logarithm of the regression coefficient) and its 95% confidence interval. Probability values not greater than 0.05 were regarded as significant. Data analysis was performed using the BMDP statistical software package.³³

RESULTS

Description of the population

A total of 134 dental technicians and 131 control subjects were included. Table 1 shows the main characteristics of the subjects in both groups, together with information on prevalence of exposure. The mean duration of exposure in dental work was 16.5 years (SD 11). There was no significant difference between the groups for age (mean age 36.6 years in dental technicians (SD 10.6) and 37.1 years in non-exposed group (SD 10.3); *p* = 0.7), sex (92 men (68.7%) and 42 women (31.3%) in dental technicians, 89 men (67.9 %) and 42 women (32.1%) in non-exposed group; *p* = 0.9), smoking status (non-smokers, current smokers, and ex-smokers; *p* = 0.2), and mean pack years in current smokers (11 (SD 14.1) in dental technicians, 11.8 (SD 10.9) in non-exposed group; *p* = 0.8).

Comparisons between dental technicians and non-exposed workers

Respiratory symptoms

A total of 256 subjects filled in the medical questionnaire. Sex and age had no influence on respiratory symptoms. Smoking increased the prevalence of "being woken by cough" (19.6% for smokers and ex-smokers versus 8.7% for non-smokers; OR = 2.5, 95% CI: 1.1 to 5.5) and of "usual morning cough" (11.8% for smokers and ex-smokers versus 3.9% for non-smokers; OR = 3.6, 95% CI: 1.2 to 11.2).

Table 2 shows the prevalence of respiratory symptoms in both groups adjusted for smoking habits, sex, age, and exposure to asbestos in the past. The prevalence of usual phlegm and cough (day and night) was consistently and significantly higher in the exposed group (OR = 7.1, 95% CI: 1.4 to 36.5, and OR = 2.9, 95% CI: 1.1 to 8.1, respectively).

Respiratory function

A total of 128 dental technicians and 121 non-exposed subjects underwent spirometry. Ten dental technicians and 17 control subjects were excluded from spirometric analysis because of poor tracings in accordance with the quality criteria used.³⁴ Quality of respiratory function measurements (expressed as acceptable or not acceptable) was not significantly different in the two groups (*p* = 0.2). Controls who were not included in the spirometry analyses were not different for sex (*p* = 0.7), smoking habits (*p* = 0.7) or respiratory symptoms (*p* > 0.2) from those who were included in the analyses.

Table 3 shows the results of the respiratory function in exposed and non-exposed groups according to sex, smoking habits, and exposure to asbestos in the past; % FVC, % FEF₂₅, and % FEF₅₀ were lower in dental technicians than in control subjects. Smoking had a negative influence on lung function with a significant decrease on all the parameters except % FEF₂₅₋₇₅. There was a positive interaction between smoking and exposure (being a dental technician) for all spirometric parameters.

Chest x rays

A total of 213 subjects underwent a chest x ray examination, 108 in the exposed group and 105 in the non-exposed group. Four films could not be read because of their poor quality (two in each group). Controls who were not included in the radiograph analyses were not different for sex (*p* = 1), smoking habits (*p* = 0.6), or respiratory symptoms from those who

Table 1 Description of the study population

	Dental technicians		Control subjects	p value
Age (y)	(n=134)		(n=131)	0.7*
Mean (SD)	36.6 (10.6)		37.1 (10.3)	
Sex	(n=134)		(n=131)	0.9†
Male, n (%)	92 (68.7)		89 (67.9)	
Female, n (%)	42 (31.3)		42 (32.1)	
Smoking	(n=132)		(n=124)	0.8*
Non-smokers, n (%)	61 (46.2)		42 (33.9)	
Ex-smokers, n (%)	26 (19.7)		33 (26.6)	
Smokers ≤ 10 P-Y, n (%)	30 (22.7)		31 (25)	
Smokers > 10 P-Y, n (%)	15 (11.4)		18 (14.5)	
Mean P-Y (SD)	11 (14.1)		11.8 (10.9)	
Exposure	n (%)	Mean duration (SD)‡	n	
Asbestos	63 (47)	20.7 (9.4)	0	
Beryllium	32 (23.9)	23.5 (11.4)	0	
Silica	104 (78.9)	16.3 (10.8)	0	
Resin	105 (78.3)	14.6 (12.1)	0	
Plaster	125 (93.3)	15.9 (11)	0	
Wax	112 (83.6)	16 (11.3)	0	
Ceramic	51 (38)	7.8 (11.9)	0	
Nickel-chromium alloys	110 (82.1)	15.5 (11.6)	0	
Chromium-cobalt alloys	72 (53.7)	12.2 (12.5)	0	

P-Y, pack years.

*t test for quantitative variables.

†χ² test for qualitative variables.

‡Calculated on dental technicians who have been exposed.

Table 2 Prevalence of respiratory symptoms in exposed and non-exposed groups

Symptoms	Dental technicians (n=132)	Control subjects (n=124)	OR (95% CI)*	p value
Personal respiratory history	22 (16.7)	12 (9.7)	1.4 (0.5 to 3.7)	0.5
Personal atopy	71 (53.8)	62 (50)	0.9 (0.5 to 1.7)	0.8
Asthma (self reported)	17 (12.9)	12 (9.7)	1.1 (0.4 to 3)	0.9
Asthma (doctor), E	13 (9.8)	12 (9.7)	0.5 (0.2 to 1.8)	0.3
Attack of asthma, LY	4 (3)	1 (0.8)	3.9 (0.3 to 46.9)	0.3
Medications for asthma	9 (6.8)	2 (1.6)	2 (0.2 to 14.9)	0.5
Attack of SOB at rest, LY	5 (3.8)	3 (2.4)	0.8 (0.1 to 8)	0.8
Woken by SOB, LY	2 (1.5)	1 (0.8)	2.1 (0.1 to 37.9)	0.6
Woken by cough, LY	17 (12.9)	22 (17.7)	0.6 (0.2 to 1.5)	0.2
Wheezing, LY	14 (10.6)	13 (10.5)	0.4 (0.1 to 1.4)	0.1
Wheezing with breathlessness, LY	9 (6.8)	9 (7.3)	0.2 (0.1 to 1.7)	0.07
Wheezing apart from a cold, LY	8 (6.1)	4 (3.2)	0.4 (0.1 to 4.1)	0.4
Morning SOB, LY	13 (9.8)	11 (8.9)	0.3 (0.1 to 1.6)	0.1
Usual morning cough	12 (9.1)	10 (8.1)	2.5 (0.9 to 7)	0.07
Cough day and night	17 (12.9)	8 (6.5)	2.9 (1.1 to 8.1)	0.03
Chronic cough	8 (6.2)	4 (3.2)	2.4 (0.5 to 10.3)	0.2
Usual phlegm	14 (10.6)	2 (1.6)	7.1 (1.4 to 36.5)	0.008
Chronic bronchitis	8 (6.1)	2 (1.6)	3.3 (0.5 to 21.5)	0.2
Chronic cough or phlegm	14 (10.6)	5 (4)	3 (0.8 to 10.5)	0.09
Dyspnoea	24 (18.2)	8 (6.5)	2.3 (0.8 to 6.6)	0.1

Percentages in parentheses.

E, ever; LY, last year; SOB, shortness of breath.

*Odds ratio (95% CI) for dental technicians versus control subjects adjusted for smoking in two classes, sex, age, and exposure to asbestos in the past in two classes by logistic regression analysis.

were included in the analyses ($p > 0.08$). Table 4 shows the prevalence of radiographic abnormalities; 8.5% of dental technicians and 1.9% of control subjects had small bilateral opacities, with no significant difference after adjusting for smoking, age, sex, and exposure to asbestos in the past in two classes (having or not been exposed). Small opacities with profusion classified 1/0 or greater were higher among dental technicians (12.3% versus 1.9%) without a significant difference after adjusting for smoking, age, sex, and exposure to asbestos in the past in two classes (having or not been exposed). The prevalence of small bilateral opacities, large opacities, and pleural involvement increased significantly with age (OR = 1.1 per year, 95% CI: 1 to 1.3, OR = 1.1, 95% CI: 1 to 1.3, and

OR = 1.1, 95% CI: 1 to 1.2, respectively), after adjusting for smoking, age, sex, and exposure to asbestos in the past in two classes (having or not been exposed).

Comparisons within dental technicians

Symptoms more frequent in dental technicians compared to control subjects (cough (day and night) and usual phlegm, table 2) did not increase with duration of dental work in dental technicians (table 5). Although the prevalence of attack of wheezing was not significantly higher in dental technicians than in control subjects (table 2), a significant increase was observed with duration of exposure to dental manufacture (OR = 7.1, 95% CI: 0.9 to 54.4) (table 5).

Table 3 Respiratory function in exposed and non-exposed groups

	% FVC	% FEV ₁	% FEF ₂₅₋₇₅	% FEF ₂₅	% FEF ₅₀	% FEF ₇₅	% PF
Exposure	-1.42**	0.05 (NS)	-0.27 (NS)	-1.57**	-2.75***	-0.08 (NS)	1.85***
Sex	-2.48***	-0.72 (NS)	3.29***	-0.59 (NS)	2.10***	1.64***	-4.89***
Smoking	-2.83***	-1.99***	0.05 (NS)	-3.80***	-2.18***	-2.68***	-10.95***
Asbestos	-1.05*	0.42 (NS)	0.28 (NS)	-2.70***	1.35**	5.21***	1.43**
Exposure-sex	-2.03***	-1.17**	-3.05***	-7.17***	-4.23***	1.63***	-0.78 (NS)
Exposure-smoking	-2.74***	-4.96***	-9.09***	-11.43***	-6.39***	-3.32***	1.18**
Sex-smoking	-1.83***	-0.16 (NS)	3.69***	1.47**	1.99***	-1.50**	7.56***
Constant	97.2	100.5	104.6	109.9	99.6	99.7	103.7
r ²		0.02	0.01	0.02			0.02

Multiple linear regression adjusted for exposure (being a dental technician), asbestos (having been exposed to asbestos in the past), sex (being a male), smoking habits in two classes (smokers and ex-smokers versus non-smokers), and interactions between exposure to dental work and being a male, exposure to dental work and smoking, being a male and smoking. All listed variables were simultaneously included in the model. Regression coefficients and p values are shown.

Results expressed as mean (SD) percentage of the ECSC reference values calculated in relation to sex, age, and height.

FVC, forced vital capacity; FEV₁, forced expiratory volume in one second; FEF₂₅₋₇₅, forced mid expiratory flow; FEF₂₅, FEF₅₀, FEF₇₅, maximal flow rates at 25%, 50%, and 75% of exhaled FVC; PF, peak flow rate.

*p<0.05, **p<0.01, ***p<0.001.

Table 4 Prevalence of radiographic signs in exposed and non-exposed groups

	Dental technicians (n=106)†	Control subjects (n=103)†	OR (95% CI)*	p value
Small bilateral opacities	9 (8.5)	2 (1.9)	1.7 (0.2 to 13.5)	0.6
Profusion ≥ 1/0	13 (12.3)	2 (1.9)	3.1 (0.2 to 52.2)	0.4
Large opacities	4 (3.8)	1 (1)	3.8 (0.3 to 46.5)	0.3
Pleural involvement	8 (7.7)	5 (4.9)	1.6 (0.3 to 7.5)	0.6
Signs related to pneumoconiosis‡	13 (12.3)	6 (5.8)	2.4 (0.8 to 7.4)	0.1
Other additive signs§	28 (26.4)	18 (17.5)	1.8 (0.9 to 3.7)	0.1

*Odds ratio (95% CI) for dental technicians versus non-exposed subjects adjusted for smoking in two classes, sex, exposure to asbestos in the past, and age by logistic regression analysis.

†Percentages in parentheses.

‡In accordance with the ILO classification.

§Not related to pneumoconiosis.

Table 5 Prevalence of respiratory symptoms in dental technicians by duration of dental work in two groups according to the median

Symptoms	Duration ≤ 15 y (n=67)	Duration > 15 y (n=65)	OR (95% CI)*	p value
Mean age, y (SD)	29.3 (8.3)	44.1 (6.9)		0.00001†
Asthma (self reported)	9 (13.4)	8 (12.3)	1.1 (0.2 to 5.5)	0.9
Asthma (doctor), E	7 (10.4)	6 (9.2)	0.9 (0.1 to 5.8)	0.9
Attack of asthma, LY	2 (3)	2 (3.1)	1.7 (0.1 to 47.2)	0.7
Medications for asthma	3 (4.5)	6 (9.2)	2 (0.2 to 21.5)	0.6
Attack of SOB at rest, LY	0	5 (7.7)	0	0.2
Woken by SOB, LY	1 (1.5)	1 (1.5)	0.2 (0.1 to 9.9)	0.4
Woken by cough, LY	5 (7.5)	12 (18.5)	2.4 (0.5 to 12.4)	0.3
Wheezing, LY	3 (4.5)	11 (16.9)	7.1 (0.9 to 54.4)	0.04
Wheezing with breathlessness, LY	2 (3)	7 (10.8)	6.4 (0.5 to 79.4)	0.1
Wheezing apart from a cold, LY	2 (3)	6 (9.2)	2.8 (0.3 to 30.7)	0.4
Morning SOB, LY	3 (4.5)	10 (15.4)	2.1 (0.3 to 15.2)	0.4
Usual morning cough	4 (6)	8 (12.3)	2.7 (0.4 to 16.5)	0.3
Cough day and night	6 (9)	11 (16.9)	1.8 (0.4 to 8.5)	0.4
Chronic cough	2 (3)	6 (9.2)	3.4 (0.3 to 37.5)	0.3
Usual phlegm	6 (9)	8 (12.3)	2.1 (0.4 to 11.5)	0.4
Chronic bronchitis	2 (3)	6 (9.2)	4.1 (0.3 to 51.3)	0.2
Chronic cough or phlegm	3 (4.5)	11 (16.9)	5.5 (0.8 to 38.6)	0.06
Dyspnoea	10 (14.9)	14 (21.5)	0.6 (0.2 to 2.3)	0.5

Percentages in parentheses.

E, ever; LY, last year; SOB, shortness of breath.

*Odds ratio (95% CI) for dental technicians with duration of dental work >15 years versus those with duration of exposure ≤15 years adjusted for smoking in two classes, sex, age, and exposure to asbestos in the past (having or not been exposed to asbestos in the past) by logistic regression analysis.

†Student's t test.

The prevalence of the symptoms was not found to be different between dental technicians manufacturing metal prostheses (n = 16) and technicians manufacturing metal and resin prostheses (n = 116) (results not shown).

Twenty one dental technicians (16.4% of the exposed population) complained about symptoms related to occupational

tasks (cough (n = 17), shortness of breath (n = 6), or wheezing (n = 2)) during or after a day of work. None of these symptoms were significantly associated with current occupational exposure (exposure to plaster, refractory material, wax, metal alloys, resin, or ceramic expressed as present or absent). Those complaining about shortness of breath after a day of

work did have a lower % FEF₇₅ compared to other technicians ($p = 0.03$). One subject complained of wheezing during his work; all his spirometric parameters were decreased except % FEF₇₅. The mean peak flow percentage of the two technicians complaining about wheezing after a day of work decreased significantly compared to the other technicians who did not report this symptom (76% of the ECSC reference value (SD 1.4) versus 100.2% (SD 19.7), $p < 0.00001$).

After adjusting for smoking in two classes, age, sex, and exposure to asbestos in the past in two classes (having or not been exposed), the prevalence of small opacities and pleural involvement in dental technicians with 15 years or more of duration of dental work was not significantly higher than in those with less than 15 years of exposure (25% versus 10%, $p = 0.8$ for small opacities, 14.5% versus 0%, $p = 0.07$ for pleural involvement). Without reference to duration of work, in dental technicians with small and bilateral opacities, all the spirometric parameters except the peak flow percentage, were significantly lower ($p = 0.02$). When large opacities were present, all the parameters except % FEV₁ and % FEF₅₀ were significantly lower ($p = 0.04$).

There was no relation between pathological radiographs and immediate or delayed symptoms related to occupational tasks. Dyspnoea and morning shortness of breath were significantly related to small bilateral opacities (OR = 6.8, 95% CI: 1.6 to 28.4, and OR = 6.4, 95% CI: 1.3 to 31.4, respectively). Large opacities were related to medications for asthma (OR = 24, 95% CI: 2.7 to 216.8), wheezing apart from a cold (OR = 24, 95% CI: 2.7 to 216.8), morning shortness of breath (OR = 13.3, 95% CI: 3 to 109.1), and usual phlegm (OR = 10.1, 95% CI 1.3 to 80.6).

Among dental technicians with a profusion of small opacities $\geq 1/0$, there was a significantly higher prevalence of exposure to asbestos in the past, compared to dental technicians with opacities less than 1/0 (20.4% of the 49 dental technicians exposed to asbestos in the past versus 5.4% of the 55 dental technicians not exposed to asbestos in the past, OR = 16.7, 95% CI: 1.4 to 203.9). There was no difference for sex, age, smoking habits, type and size of the laboratory, and exposure to silica, beryllium, nickel–chromium and chromium–cobalt alloys or ceramic (results not shown). Large opacities and pleural involvement were not related to a particular exposure in the past.

DISCUSSION

This study shows dental technicians in Bourgogne and Franche-Comté have an excess of respiratory symptoms. Small opacities with profusion $\geq 1/0$ were associated with an exposure to asbestos in the past. The spirometric parameters were lower in dental technicians than in the non-exposed group. Radiographic abnormalities were associated with a higher prevalence of respiratory symptoms and a significant reduction of the spirometric parameters.

Eighty one per cent of the laboratories included had less than five salaried employees, similar to that in the whole of France. It is therefore our opinion that results should not be distorted by a possible selection bias. Nevertheless, a healthy worker effect should be envisaged as relatively healthy individuals are likely to remain employed. Dental technicians who have left their employment because of an occupational respiratory disease were not considered for this cross sectional study.

Twenty six chest x rays were missing from the dental technicians group. These subjects are not known for having occupational lung diseases, but previous studies have shown that respiratory symptoms and function can be normal, even in the case of pneumoconiosis. Those missing data could underestimate the prevalence of radiographic abnormalities in this group. The control sampling seems adequate, regarding

demographic characteristics and smoking habits, as no difference was found between the exposed and non-exposed groups. The main limitation of our study is that it has a relative lack of statistical power (although some significant results were found).

Our study showed a significant risk of cough (day and night) and usual phlegm in dental technicians. Sherson *et al* found in a small sample (31 dental technicians versus 30 control subjects), a higher although non-significant prevalence of dyspnoea among dental technicians.²⁰

In other previous studies,^{19 20 26} the respiratory function parameters decreased slightly in the dental technicians group although there was no statistical significant difference between the two groups. In our study, the mean values for % FCV, % FEF₂₅, and % FEF₅₀ decreased significantly in male dental technicians. There was a positive interaction between smoking and exposure for the decrease of all spirometric parameters.

The prevalence of small opacities with a profusion $\geq 1/0$ (12.3% for a mean duration of dental work of 16.5 years) was somewhat higher than the prevalence reported in the previous studies (11.8% for a mean duration of 28.4 years for Choudat and colleagues,¹⁹ 12.9% for a duration of 20 years for Sherson and colleagues,²⁰ 4.5% for a mean of 12.8 years of exposure for Rom and colleagues¹⁷). The dental technician population studied in Bourgogne and Franche-Comté is young (mean age 36.6 years) but surprisingly, the prevalence of pneumoconiosis is high compared to other studies. In particular, the prevalence was similar compared to Choudat and colleagues' study, whose target population were older (mean age 46.9 years) than our population and were self employed dental technicians. There is already an effect of lung abnormalities on respiratory symptoms and spirometric parameters. Our study found a relation between small opacities and an exposure to asbestos in the past; we found no significant relation between radiographic signs and a particular type of prosthesis manufactured by the dental workers (metal, ceramic, or resin). Sherson *et al* showed that dental technicians with pneumoconiosis were employed in the production of chromium–cobalt prostheses.²⁰ In the study by Rom *et al* there was a relation between pneumoconiosis and exposure to metal alloys.¹⁷ Numerous airborne contaminants can be generated during manufacture of the prostheses, and association between pneumoconiosis and a specific agent is difficult to show.

In most small laboratories, there is no suitable exhaust and ventilation system in workplaces, so that many processes used by dental technicians probably expose them to numerous dangerous airborne contaminants responsible for complex pneumoconiosis, particularly to silica during preparation of refractory material, breaking of the mould, sandblasting, and polishing. Hand finishing exposes them to metal alloys, beryllium, and resin. Most of the current chromium–cobalt alloys are free of beryllium but their exact composition is not always known.

The signs of early morbidity increasing with the duration of work in dental manufacture are worrying. Most dental technicians start working at the age of 18 and do not change their employment. Moreover, this population is still at risk of pneumoconiosis. This study confirms the need for adequate technical prevention measures, control of occupational exposure, and the replacement of dangerous material when possible (silica, heavy metals, beryllium).

Authors' affiliations

S Radi, M P Leboube, Association Comtoise Interprofessionnelle de Médecine du Travail, 5 A rue Victor Sellier, 25041 Besançon Cedex, France

J C Dalphin, D Pernet, Department of Respiratory Disease, University Hospital, Boulevard Fleming, 25030 Besançon Cedex, France

P Manzoni, Department of Radiology C, University Hospital, Place Saint Jacques, 25030 Besançon Cedex, France

REFERENCES

- 1 **Choudat D**. Occupational lung diseases among dental technicians. *Tubercle* 1994;**75**:99–104.
- 2 **Guide Pratique de Ventilation**. No. 16. ED 760. Ateliers de fabrication de prothèses dentaires. *Cahiers de notes documentaires, INRS* 1992;**149**:437–454.
- 3 **Peltier A**, Kauffer E, Moulut JC, et al. Pollution dans les ateliers de prothèse dentaire. *Cahiers de notes documentaires, INRS* 1991;**143**:263–76.
- 4 **Peltier A**, Moulut JC, Demange M. Le risque de pneumoconiose chez les techniciens-dentistes. *Travail et Sécurité* 1979;**3**:166–8.
- 5 **Hou A**. Poussières dans les ateliers de prothèse dentaire: risque et prévention. *Sécurité et Médecine du Travail* 1989;**86**:20–5.
- 6 **Soulat JM**, Marpinard M, Esquirol Y, et al. Exposition à la silice chez les prothésistes dentaires. *Arch Mal Prof* 2000;**61**:156–61.
- 7 **Briotet L**, Le Magrex L, Parant C, et al. Les risques de silicose chez les prothésistes dentaires. *Arch Mal Prof* 1979;**40**:122–3.
- 8 **Moulin C**, Rousson I, Monestier F, et al. Persistance du risque silicotique chez les prothésistes dentaires. A propos de cinq cas. *Arch Mal Prof* 1986;**47**:270–6.
- 9 **Ollagnier C**, Tolot F, Perrin LF, et al. Une observation de silicose chez un mécanicien dentiste. *Arch Mal Prof* 1962;**23**:385–6.
- 10 **Poncin B**, Le Magrex L, Poncin JM. Silicose chez les prothésistes dentaires. *Arch Mal Prof* 1983;**44**:430–4.
- 11 **Morgenroth K**, Kronenberger H, Michalke G, et al. Morphology and pathogenesis of pneumoconiosis in dental technicians. *Pathol Res Pract* 1985;**179**:528–36.
- 12 **Sherson D**, Maltbaek N, Heydorn K. A dental technician with pulmonary fibrosis: a case of chromium-cobalt alloy pneumoconiosis. *Eur Respir J* 1990;**3**:1227–9.
- 13 **Selden AI**, Shale W, Johansson L, et al. Three cases of dental technician's pneumoconiosis related to chromium-cobalt-molybdenum dust exposure. *Chest* 1996;**109**:837–42.
- 14 **Selden AI**, Persson B, Bornberger Dankvardt SI, et al. Exposure to cobalt chromium dust and lung disorders in dental technicians. *Thorax* 1995;**50**:769–72.
- 15 **Kotloff RM**, Richman PS, Greenacre JK, et al. Chronic beryllium disease in a dental laboratory technician. *Am Rev Respir Dis* 1993;**147**:205–7.
- 16 **Müller Quernheim J**, Zissel G, Schopf R, et al. Differential diagnosis of berylliosis/sarcoidosis in a dental technician. *Dtsch Med Wochenschr* 1996;**121**:1462–6.
- 17 **Rom WN**, Lockey JE, Lee JS, et al. Pneumoconiosis and exposures of dental laboratory technicians. *Am J Public Health* 1984;**74**:1252–7.
- 18 **Sulotto F**, Romano C, Berra A, et al. Pneumoconioses chez les prothésistes dentaires. Observations cliniques, radiologiques et contrôles atmosphériques. *Arch Mal Prof* 1987;**48**:283–8.
- 19 **Choudat D**, Triem S, Weill B, et al. Respiratory symptoms, lung function, and pneumoconiosis among self employed dental technicians. *Br J Ind Med* 1993;**50**:443–9.
- 20 **Sherson D**, Maltbaek N, Olsen O. Small opacities among dental laboratory technicians in Copenhagen. *Br J Ind Med* 1988;**45**:320–4.
- 21 **Charles P**, Fabre J, Pujol M, et al. Duprez. Pneumoconioses complexes chez les prothésistes dentaires. *Poumon et Coeur* 1978;**34**:189–92.
- 22 **De Vuyst P**, Vande Weyer R, De Coster A, et al. Dental technician's pneumoconiosis. A report of two cases. *Am Rev Respir Dis* 1986;**133**:316–20.
- 23 **Nayebzadeh A**, Dufresne A, Harvie S, et al. Mineralogy of lung tissue in dental laboratory technician's pneumoconiosis. *Am Ind Hyg Assoc J* 1999;**60**:349–53.
- 24 **Lob M**, Hugonnaud C. Risques de pneumoconiose par métal dur et de béryllose chez les techniciens-dentistes lors de l'usage de prothèses métalliques. *Arch Mal Prof* 1977;**38**:543–9.
- 25 **Brancaleone P**, Weynand B, De Vuyst P, et al. Lung granulomata in a dental technician. *Am J Ind Med* 1998;**34**:628–31.
- 26 **Froudarakis ME**, Voloudaki A, Bouros D, et al. Pneumoconiosis among Cretan dental technicians. *Respiration* 1999;**66**:338–42.
- 27 **Tuengerthal S**, Kronenberger H, Meyer-Sydow J, et al. Radiological findings in chest X-ray examinations of dental technicians. *Proceedings of the sixth International Pneumoconiosis Conference*. Bochum, 1983:1201–10.
- 28 **Szadkowski D**, Zietz M, Angerer J, et al. Gesundheitsgefahren durch Stäube in Dentallabor. Teil II : Befunde einer arbeits-medizinischen Untersuchung von Zahntechnikern. *Arbeitsmed Socialmed Präventivmed* 1987;**22**:29–33.
- 29 **Burney P**, Luczynska S, Chinn S, et al. The European Community Respiratory Health Survey. *Eur Respir J* 1994;**7**:954–60.
- 30 **American Thoracic Society**. Standardization of spirometry: 1987 update. *Am Rev Respir Dis* 1987;**136**:1285–98.
- 31 **Quanjer PH**. Standardised lung function testing. *Bull Eur Physiopathol Respir* 1983;**19**(suppl 5):1–95s.
- 32 **Bureau International du Travail**. *Instructions pour l'utilisation de la classification internationale du BIT des radiographies de pneumoconioses*, revised edn. Geneva: Bureau International du Travail, 1980.
- 33 **BMDP Statistical Software**. Version 7.0. Berkeley: University of California Press, 1993.
- 34 **American Thoracic Society**. Lung function testing: selection of reference values and interpretative strategies. *Am Rev Respir Dis* 1991;**144**:1202–18.