Respiratory morbidity in a population of French dental technicians

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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. 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. The risk is associated with inadequate local exhaust and ventilation, especially for the preparation of plaster and refractory material, wax modling, fusion of alloys, sanding, and hand finishing. In France, there are about 14 000 dental technicians working in 4500 dental laboratories. 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, 2–5 heavy metals, 6–10 or beryllium 11–13 have been reported. 14–16 In addition, because of concomitant exposures, complex pneumoconioses have been described associating heavy metals and silica, 17,18 cobalt and beryllium, 19 or beryllium and aluminium. 20 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. 21 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. 22 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
Italy. 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 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. 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. 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. 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. Their cases were selected from hospitalised dental technicians. Szadowski et al found three cases of pneumoconiosis in a group of 149 dental technicians. 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 France: 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 prosthetic 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 prosthetics 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 attend ance of a dental technician participating in the study matched for age ± 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.

“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 expectation 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 laboratory 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. 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 non-exposed participants. Ten dental technicians and 17 control subjects underwent spirometry. Ten dental technicians and 17 control subjects were regarded as significant. Data analysis was performed using the BMDP statistical software package.

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, 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 two classes (having been exposed or not). 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.” 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, % FEV1, and % FEF25% 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%. 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
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).
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 plastic, refractory material, wax, metal alloys, resin, or ceramic expressed as present or absent). Those complaining about shortness of breath after a day of work were significantly associated with current occupational exposure (exposure to plastic, refractory material, wax, metal alloys, resin, or ceramic expressed as present or absent).
work did have a lower % FEV₁ compared to other technicians (p = 0.03). One subject complained of wheezing during his work; all his spirometric parameters were decreased except % FEF₂₀. 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 % FEF₂₀ 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 = 101, 95% CI 1.3 to 80.6).

Among dental technicians with a profusion of small opacities ≥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 ≥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.

In other previous studies,⁻¹⁷⁻²⁰ 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, % FEF₂₀, and % FEF₂₀ 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 ≥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,⁻¹⁷ 12.9% for a duration of 20 years for Sherson and colleagues,⁻¹⁸ 4.5% for a mean of 12.8 years of exposure for Rom and colleagues).⁻¹⁹ 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.⁻²⁰ 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).
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