Respiratory symptoms, lung function, and pneumoconiosis among self employed dental technicians

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Abstract
From the registry of self employed workers living in Paris, a group of 105 dental technicians was studied to evaluate occupational exposure, to determine respiratory manifestations, and to investigate immune disturbances. Seventy one dental technicians (age range 43–68: group D), 34 dental technicians younger than 43 or older than 68 (group d), and 68 control workers (age range 43–66: group C) were investigated. The demographic characteristics and the smoking habits of the groups D and C did not differ significantly. The dental technicians often worked alone (43·7%) or in small laboratories without adequate dust control. The mean duration of their exposure was long (group D 34·0 (SD 8·4) years). The prevalence of respiratory symptoms did not differ betwen groups D and C except for the occurrence of increased cough and phlegm lasting for three weeks or more over the past three years (group D 16·9%, group C 2·9%, $p < 0{\cdot}007$). The effect of cigarette smoking on respiratory symptoms and lung function was obvious. All mean values of lung function for dental technicians and controls were within normal limits. Significant decreases in all mean lung function values were found among smokers by comparison with non-smokers, however, and a positive interaction with occupational exposure was established. The *x* ray films of dental technicians (n = 102, groups D and d) were read independently by four readers and recorded according to the International Labour Office classification of pneumoconioses. The prevalence of small opacities greater than 1/0 was 11·8% with a significant increase with duration of exposure. The prevalence among dental technicians with 30 years of exposure or more was significantly higher (22·2%) than those with less than 30 years (3·5, $p < 0{\cdot}004$). The prevalence of autoantibodies (rheumatoid factors, antinuclear antibodies, and antihistone antibodies) was not significantly different in the groups D and C. When positive, autoantibodies only occurred at low concentrations. This finding contrasts with previous reports on the occurrence of autoantibodies and even of connective tissue diseases in dental technicians. In conclusion, the study confirms an increased risk of pneumoconiosis among dental technicians. Moreover, there may be other lung disorders such as impairment of lung function especially in association with cigarette smoking.

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Dental technicians are exposed to several fibrogenic dusts and many cases of pneumoconiosis have been reported since 1962.[1-5] Lung fibrosis may be induced by silica dust and probably also by other particles generated during the production of dental prostheses, such as aluminium oxide, asbestos fibres, various metals (for example, cobalt-chromium-nickel alloys, beryllium). Moreover, the question of the occurrence of rheumatoid arthritis and scleroderma among dental technicians with or without pneumoconiosis has been debated in recent years.[6-10] Surveys about lung diseases in groups of dental technicians have rarely been performed.[7] [11-13] Two studies were focused only on respiratory symptoms[14] or pneumoconiosis.[15]

The aim of our study was to evaluate occupational exposure by questionnaire, to determine the prevalence of respiratory symptoms and pneumoconiosis, to assess ventilatory impairment, and to investigate immune disturbances among dental technicians.

Subjects and methods

POPULATION

All subjects, dental technicians and controls, were selected from the Registry of the Social Insurance for self employed workers. The study was limited to the city of Paris and was conducted from September 1990 to September 1991.

All the dental technicians (n = 343), men or women, were identified through the Chamber of Crafts of Paris Registry. In September 1990, they were sent a letter inviting them to a medical check up. In April 1991, the remaining dental technicians were contacted by a second letter. From this group, 113 subjects were examined at the medical centre for self employed workers. Three women and five non-caucasian men were excluded from the analyses.

The control group was also composed of self employed workers. All the workers between 43 and 66 years old were invited to a medical check up. The control group (group C) included caucasian men, without known exposure to any air contaminant, matched by age with the dental technicians (group D).

The studied population was, therefore, composed of three groups: 68 control workers 43–66 years old (group C); 71 dental technicians 43–68 years old (group D) for the comparisons of respiratory symptoms and lung function with group C; and 33 dental technicians younger than 43 (25–42) and one 75 years old (group d) to study the effect of duration of exposure by comparison with group D.

QUESTIONNAIRES

Each subject completed a questionnaire about individual characteristics such as age, height, medical history, smoking habits, occupational history. Nonsmokers were defined as those persons smoking less than one cigarette a day and ex-smokers as those who had stopped smoking completely at least six months before the study. Questions on respiratory symptoms were adapted from the questionnaires of the British Medical Research Council and of the International Union Against Tuberculosis and Lung Disease: usual and morning cough, phlegm, wheezing during the last 12 months, shortness of breath, description of the statement of breathing. Further questions on work related symptoms such as rhinitis, irritation in the eyes, and respiratory symptoms were included. A second questionnaire about occupational history was completed by the dental technicians to provide information on materials, processes, and prevention.

PULMONARY FUNCTION TESTS

Measurement of pulmonary function was carried out with a computerised spirometer (Vicatest VCT 4, Mijnhardt). At least three readings were obtained with the subject seated and wearing a nose clip.

The highest forced vital capacity (FVC), highest forced expiratory volume during one second (FEV_1), and highest peak flow rate (PF) were recorded, not necessarily from the same test. The other forced expiratory flow rates were taken from the curve with the highest sum of the FVC and FEV_1: forced expiratory flow during the middle half of the FVC (FEF_{25-75}), and maximal flow rates at points of the curve where 75%, 50%, and 25% of the FVC were still to be expired (FEF_{75}, FEF_{50}, and FEF_{25}).

Lung function values were expressed as percentage of predicted values from the European Committee for Coal and Steel. All values were adjusted for age and height using regressions on the groups D and C. The standardised deviation was used—that is, the observed value minus the predicted value divided by the residual standard variation.

x RAY FILM READING

The *x* ray films (n = 102, groups D and d) were read independently by a panel of four readers. The films were recorded according to the International Labour Office (ILO) classification of radiographs of pneumoconiosis, revised 1980. For evaluation of mean profusion, the 12 point scale of ILO was used and a numerical score was calculated for each film by averaging the four readings. Decimal values between two close categories were pooled with the inferior category for the expression of the results.

BIOLOGICAL DATA

Blood from dental technicians (group D) and control subjects (group C) was obtained by venous puncture. Serum was screened for rheumatoid factors, antinuclear antibodies, and antihistone antibodies. The rheumatoid factors were simultaneously assayed by the red cell agglutination test (RCAT)[16] and an enzyme linked immunosorbent assay (ELISA).[17] Results of the RCAT were expressed as the ultimate positive serum dilution (n < 1:32); results of the ELISA were expressed as units *v* a reference serum (Serascan, Boehringer-Mannheim, France; n < 10 units).

Antihistone antibodies were screened on rat liver sections by immunofluorescence.[18] When they were found positive at a dilution ⩾ 1 : 50, more precise specificities were looked for: anti-dsDNA antibodies were searched by immunofluorescence on *Crithidia luciliæ*[19] (n < 1 : 20) and ELISA[20] (n < 10 units); antibodies to extractible nuclear antigens (ENA) such as RNP, Sm, Ro/SS-A, La/SS-B, Jo1, and Scl 70, were searched by counterimmunoelectrophoresis[21]; anticentromere antibodies were

Table 1 Demographic characteristics of the three groups

	Group d (n = 33)	*Group D (n = 71)*	*Group C (n = 68)*
Age (y; mean (SD))	35·6 (4·6)	52·2 (7·1)	52·8 (5·8)
Height (cm; mean (SD))	173·5 (6·5)	171·1 (5·8)	172·6 (5·6)
Weight (kg; mean (SD))	76·8 (11·6)	77·9 (12·0)	77·9 (11·8)
Duration of exposure (y; mean (SD))	15·9 (5·5)	34·0 (8·4)	—
Non-smoker (No (%))	15 (45·4)	21 (29·6)	18 (26·5)
Smoker (No (%))	12 (36·4)	28 (39·4)	27 (39·7)
Ex-smoker (No (%))	6 (18·2)	22 (31·0)	23 (33·8)

detected by immunofluorescence on Hep-2 cells.[22] Also, IgG and IgM anticardiolipin antibodies were measured by ELISA (n < 15 units.[23] IgG and IgM antihistone antibodies were assayed by ELISA[24] and the results expressed as the ultimate positive dilution (n < 1 : 50).

STATISTICAL ANALYSIS

Standard descriptive statistics were used to represent responses. χ^2 Tests were used with 2 × 2 contingency tables to determine whether relations shown between such variables were statistically significant. Analysis of variance was used to examine the relation of respiratory symptoms, work exposure, and smoking to pulmonary function.

Results

The dental technicians often worked alone (43.7% of the laboratories) or in small laboratories with few wage earners (median 2, range 1–12).

The mean duration of exposure was long (table 1). This is in agreement with the finding that most of the subjects started to work early, at the age of about 18, and that the turnover was low. They considered their occupational risk as moderate (66·7%) or great (39·4%) and were interested in a medical survey adapted to these risks (98·1%).

They used the process of *fonte en cire perdue* or wax model casting with various non-precious (89·5%) or precious alloys (83·8%). Alloys containing beryllium have been used by 44·8%. Most of the dental technicians employed ceramics (76·2%), various resins (80·0%), and cyanoacrylate glue (92·4%).

After casting, abrasive sandblasters were used (95·2%) with aluminium oxide (91·4%) and also with sand (24·8%). Various acids were used (chlorhydric 59·0%; fluorhydric 39·0%; sulphuric 38·1%) and also organic solvents (acetone 39·0%; trichlorethylene 29·5%; ethyl acetate 21·0%).

Fifteen laboratories had no ventilation. Ventilation systems were more frequent when the dental technician worked with a wage earner than when he was by himself (61·4% *v* 21·4%, p = 0·005).

Table 1 shows the demographic characteristics of the population. Groups D and C did not differ significantly. The smoking habits of the three groups were similar with a lower prevalence of ex-smokers among the younger dental technicians (group d).

The prevalence of respiratory symptoms did not differ between groups D and C except for the occurrence of increased cough and phlegm lasting for three weeks or more over the past three years (table 2). There was no significant difference in the prevalence of respiratory symptoms between groups d and D despite a twofold greater duration of exposure in group D. In the whole population, regardless of the occupation, smokers and ex-smokers reported a higher prevalence of respiratory symptoms than non-smokers (table 3).

All mean lung function values for dental technicians and controls were within normal limits, without significant differences between groups D and C or between groups d and D (table 4). There was no significant correlation between values for lung function controlled for age and duration of exposure. On the contrary, in the whole population significant decreases of all mean lung function values were found among smokers by comparison with non-smokers. Results of the tests of pulmonary function

Table 2 Prevalence of respiratory symptoms according to the groups

Symptom	*Group d (n = 33)*	*Group D (n = 71)*	*Group C (n = 68)*	*p Value*
Morning cough	3 (9·1)	9 (12·7)	9 (13·2)	NS
Cough day and night	2 (6·1)	4 (5·6)	7 (10·3)	NS
Cough (three months/year)	3 (9·1)	7 (9·9)	5 (7·4)	NS
Phlegm	5 (15·2)	7 (9·9)	10 (14·7)	NS
Phlegm day and night	2 (6·1)	3 (4·2)	2 (2·9)	NS
Phlegm day and night (three months/year)	1 (3·0)	4 (5·6)	5 (7·4)	NS
Cough and phlegm during three weeks	4 (12·1)	12 (16·9)	2 (2·9)	p < 0·007
Several times	3 (9·1)	9 (12·7)	2 (2·9)	p = 0·04
Dyspnoea 1	5 (15·2)	18 (25·4)	14 (20·6)	NS
Dyspnoea 2	1 (3·0)	3 (4·2)	2 (2·9)	NS
Wheezing	4 (12·1)	12 (16·9)	10 (14·7)	NS

Table 3 Prevalence of respiratory symptoms among smokers, ex-smokers, and non-smokers, regardless of occupation

Symptom	Non-smokers (n = 54)	Smokers (n = 67)	Ex-smokers (n = 52)
Morning cough	3·7	20·9 (p < 0·006)	9·6
Cough day and night	5·6	7·5	9·6
Phlegm	5·6	17·9 (p < 0·04)	13·5
Phlegm day and night	5·6	3·0	3·9
Phlegm day and night (three months/year)	7·4	10·5	13·5
Dyspnoea 1	11·1	29·9 (p = 0·01)	21·2
Dyspnoea 2	0	7·5	1·9
Wheezing	3·7	17·9 (p < 0·02)	23·1 (p < 0·002)

were compared according to the occupational exposure and the smoking habits (fig 1). All the mean normalised values were lower among the smokers and among the dental technicians than among the non-smokers and control subjects. The decreases were substantial among smokers and dental technicians with both exposures.

The conformity of readings to evaluate the quality and the profusion of the films between the four readers was good. The classification of 30 films was identical between the four readers; 52 films were either in agreement among three readers or classified by two readers in a category close to the category of the two others (for example, two 0/1 and two 1/0). Among the 102 radiographs, 12 showed small opacities with profusion of 1/0 or greater. The small opacities of the 12 dental technicians with pneumoconiosis were more often linear and irregular (s or t 57·6%) than nodular (p or q 41·3%) Only one dental technician of five subjects with film classified ⩾ 1/1 was aware of his pneumoconiosis before the survey. The prevalence of small opacities (0/1 or 1/0) was slightly higher among smokers and ex-smokers than among non-smokers (respectively 34·2% and 48·3% *v* 20·0%). The prevalence of small opacities 1/0 or greater among dental technicians with 30 years or more of exposure was significantly higher (22·2) than those with less than 30 years (3·5%, $p < 0·004$). The prevalence of small opacities 1/0 or greater increased with duration of exposure (fig 2). By contrast, the prevalence of category 0/1 was roughly constant, independent of the duration of exposure. A slight decrease in lung function controlled for age according to the radiological score was found but this was not statistically significant. Similarly, the dental technicians without pneumoconiosis (category ⩽ 0/1) had lower values for lung function than controls; again this was not significant. The prevalence of history of Raynaud's syndrome, xerostomia, and joint pain was not significantly different between groups D and C. The prevalence of IgM rheumatoid factors and antinuclear antibodies was not significantly different between groups D and C and the positive nature of the tests was always weak (table 5). There was no relation between the presence of autoantibodies and that of small opacities.

Table 4 Mean pulmonary function expressed as a percentage of European predicted values

	Group d (n = 33) Mean % pred (SD)	Group D (n = 71) Mean % pred (SD)	Group C (n = 68) Mean % pred (SD)
FVC	99·8 (14·2)	99·5 (13·4)	100·1 (14·9)
FEV_1	102·8 (12·8)	100·5 (16·1)	102·9 (18·2)
PF	109·2 (20·6)	118·6 (28·1)	113·0 (28·4)
FEF_{75}	94·5 (18·9)	93·0 (27·8)	97·4 (29·3)
FEF_{50}	107·9 (31·1)	97·7 (37·5)	103·1 (36·3)
FEF_{25}	104·6 (37·5)	95·6 (44·1)	92·3 (40·6)
$FEF_{25\ 75}$	103·8 (26·5)	95·9 (33·2)	99·9 (32·4)

Discussion

Dental technicians may be exposed to silica dust and other airborne contaminants. Although the risk of pneumoconiosis is well known, typical silicotic nodules were not seen in all cases of pneumoconiosis among dental technicians.[5 25] Thus the pathogenesis of this lung disorder may be difficult to link to a single dust exposure. These dental technicians were self employed workers particularly at risk for occupational lung disease: most worked without ventilation for more than eight hours a day. A precise exposure history was difficult to establish and the answers were rather in relation to recent exposure. The process and materials used in France, however, seemed close to the techniques used in other countries.[7 12]

As found by Rom *et al*, the prevalence of respiratory symptoms was not higher among dental technicians than among the controls.[12] By contrast with the studies of Sherson *et al*[7] we did not find significant differences in the prevalence of dyspnea grade 1 or any significant relation with duration of exposure.[14]

The influence of cigarette smoking was predominant and significant relations were found between respiratory symptoms and smoking habits.[11] The effect of cigarette smoking on lung function was also greater than the effect of occupational exposure. In agreement with Rom *et al*[12] and Sherson *et al*[7] we found slightly lower lung function among dental technicians than among control workers. These differences became significant in our study when we took occupational exposure and smoking habits into account. The positive interaction between the two agents seemed to be synergistic rather than additive (fig 1). Szadkowski *et al* did not

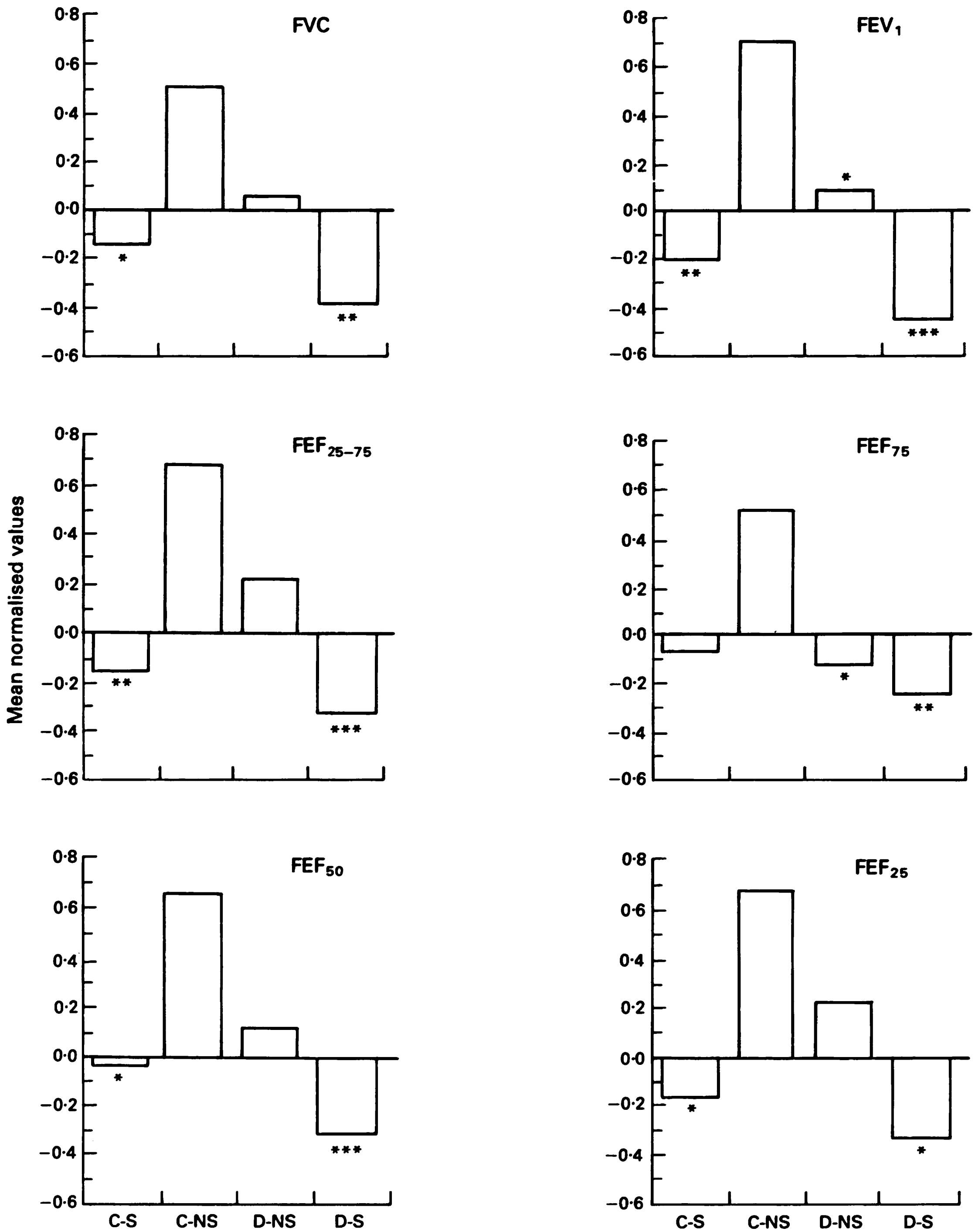

Figure 1 Mean normalised lung function values (observed—predicted/residual SD) according to exposure and smoking habits. S = smokers, NS = non-smokers, D = dental technicians, C = control workers. ($p < 0.05$; **$p < 0.01$; ***$p < 0.001$).*

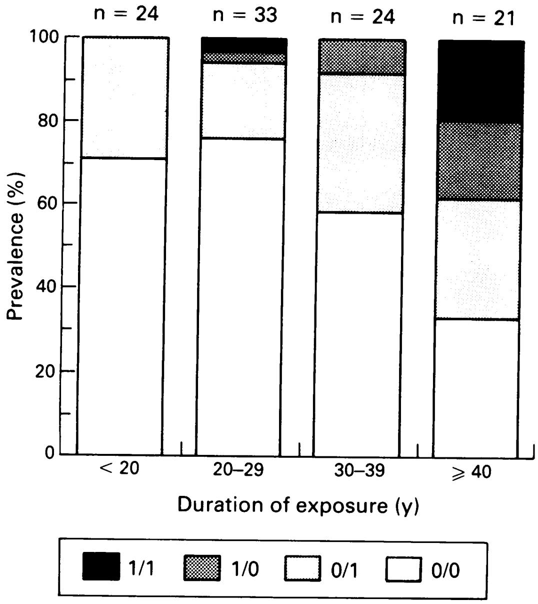

Figure 2 Prevalence of the profusion of small opacities.

find any increased risk of impairment of lung function among 149 dental technicians probably because they did not compare their data with a control group.[13]

The prevalence of small opacities (1/0 or greater) was in agreement with the results obtained by Sherson *et al*[7] in Denmark among 31 dental technicians, and by Rom *et al*[12] in Utah among 178 dental technicians if the duration of exposure was taken into account. We found a prevalence of 11·8% for a mean duration of exposure of 28·4 years, Sherson *et al* found a prevalence of 12·9% for 20 years,[7] and Rom *et al* reported a prevalence of 4·5% for only 12·8 years.[12] The prevalence of pneumoconiosis 1/0 was higher in technicians with 20 or more years of exposure. We found a prevalence of 15·4% and Rom *et al* reported a prevalence of 16·7%, significantly different from those with less than 20 years of exposure (1·4%, $p < 0·001$).[12] The prevalence of pneumoconiosis reported by Tuengerthal *et al* was higher than all the other published studies, with 38·6 to 49·5% of profusion 1/0 or greater.[15] The prevalence reached 93·5% among dental technicians with more than 20 years of exposure and 100% with more than 30 years of exposure. A recruiting bias might explain these results as most of the dental technicians included in their study were seen in a hospital. On the contrary, Szadkowski *et al* found only three cases of pneumoconiosis (0/1, 1/1, and 2/1) in a group of 149 dental technicians and they concluded that the cases of pneumoconiosis represented an old burden caused by inhalation of silica dust years ago.[13] In some studies, the duration of exposure may be too short to assume a cumulative and long term effect of dusts on the lung. The variation in rates may also be related to differences in working practices used by the population studied—for example, efficiency of control of the work environment, large or small laboratories, self employed or wage earner.

Table 5 Distribution and prevalence of autoantibodies

	Group D No (%)	*Group C No (%)*
RF RCAT ≥1 : 32	3 (4·8)	1 (1·5)
IgM RF ELISA 10–40 units	43 (69·4)	39 (57·4)
AAN 1 : 50–1 : 200	13 (21·0)	11 (16·2)
A ds DNA *Crithidia luciliæ* ≥1 : 20	0	0
A ds DNA IgG ELISA ≥10 units	0	0
Anti-ENA positive	0	0
Anticentromere positive	0	0
Anticardiolipin ≥15 units	0	0
Antihistone 1 : 50–1 : 500	9 (14·5)	10 (14·7)

Finally, dental technicians did not seem particularly at risk of autoimmune diseases. This finding contrasts with previous reports of autoantibodies and even connective tissue diseases in subjects exposed to silica[26–29]—namely, in dental technicians exposed to several dusts and in whom autoantibodies and several cases of systemic sclerosis and systemic lupus erythematosus have been described.[6–10] These reports dealt with few individual cases of dental technicians with autoimmune manifestations, however, whereas we compared a large series of randomly recruited dental technicians with a matched control group. Although no difference was found between the two groups, antinuclear antibodies, antihistone antibodies, and rheumatoid factors were occasionally detected, ruling out the use of inappropriate tests. Also, the panel of autoantibodies studied was larger than in any other previous report.

The present study has shown that the prevalence of pneumoconiosis among self employed dental technicians was high and in direct relation to duration of exposure but could not be related to a single occupational exposure. They had a slight decrease in all mean values of lung function. This decrease was intensified by cigarette smoking. By contrast, the prevalence of autoantibodies was similar to the control group. These findings for dental technicians emphasise the need for control of the work environment and medical surveillance even after retirement.

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