

# Exposure to cobalt chromium dust and lung disorders in dental technicians

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## Abstract

**Background** – Dental technician's pneumoconiosis is a dust-induced fibrotic lung disease of fairly recent origin. This study was carried out to estimate its occurrence in Sweden.

**Methods** – Thirty seven dental technicians in central and south eastern Sweden with at least five years of exposure to dust from cobalt chromium molybdenum (CoCrMo) alloys, identified by postal survey, agreed to undergo chest radiography and assessment of lung function and exposure to inorganic dust.

**Results** – Six subjects (16%; 95% confidence interval 6% to 23%) showed radiological evidence of dental technician's pneumoconiosis. The lung function of the study group was reduced compared with historical reference material. With local exhaust ventilation dust levels were generally low, whereas in dental laboratories without such equipment high levels of dust, particularly cobalt, were found.

**Conclusions** – Pneumoconiosis may result from exposure to inorganic dust in the manufacturing of CoCrMo-based dental constructions. It is possible to reduce this hazard substantially by local exhaust ventilation.

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Sporadic cases of silicosis among dental technicians have been reported since 1939.<sup>1-6</sup> More recently a new type of dust-induced fibrotic lung disease called dental technician's pneumoconiosis has been found among professionals involved in the making of metal framed removable partial dentures, usually based on various cobalt chromium molybdenum (CoCrMo) alloys.<sup>7-11</sup> However, aetiological agents have been difficult to identify since the dust exposure in dental laboratories is quite complex.<sup>12-14</sup>

High levels of cobalt in dust samples from the breathing zone of dental technicians working with CoCrMo alloys were found in a previous study and urine from exposed subjects was found to contain increased levels of cobalt.<sup>15</sup> Later an index case of dental technician's pneumoconiosis appeared in Sweden which stimulated the present cross sectional study aimed at investigating its occurrence in Sweden.

## Methods

### MEDICAL SURVEY

A questionnaire asking for the names of dental technicians who had worked with CoCrMo alloys for at least five years was mailed to all 172 dental laboratories in a defined region of central and south eastern Sweden. The catchment area has approximately two million inhabitants comprising almost 25% of the national population.

Identified subjects received standardised and self-administered questionnaires<sup>16</sup> surveying their present and previous health, respiratory symptoms, and smoking habits. Also enclosed was an ad hoc one page questionnaire regarding exposure to occupational dust. At a subsequent workplace visit by an environmental nurse the questionnaires were checked and completed, if necessary.

Lung function tests were carried out at the dental laboratories with a transportable spirometer (Compact, Vitalograph, Buckingham, UK). The instrument was calibrated at each location. The best of at least two manoeuvres for the vital capacity (VC) and the forced expiratory volume in one second (FEV<sub>1</sub>), respectively, were recorded at body temperature and pressure saturated with water vapour. Predicted lung function values were calculated from Swedish reference material<sup>17</sup> taking sex, age, and height into account.

A routine chest radiograph was performed at the nearest department of radiology, from which a radiograph from an age ( $\pm$  five years) and sex matched reference subject was also requested. The radiographs were coded and read independently by two senior physicians (one radiologist, one lung specialist) and the findings were classified according to the International Labour Office (ILO) system for radiological diagnosis of pneumoconioses.<sup>18</sup> One eligible study subject refused to participate in the radiological examination and for another subject the radiograph (normal at primary reading) could not be retrieved; thus, radiographs from 35 exposed and 21 reference subjects were available for analysis.

The survey was approved by the medical research ethics committees of the two major hospitals involved.

### ASSESSMENT OF EXPOSURE

Data sheets were obtained from producers or local suppliers of potentially dust emitting materials involved in the current manufacturing process. Dust measurements were carried out for those dental technicians who had a mini-

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Table 1 Study group characteristics (n=37)

Variable	Mean	Range
Age (years)	43.0	24-64
Years in mechanical dentistry	26.0	5-46
Hours/week	43.8	20-73
Years of work with CoCrMo	18.5	5-36
Hours/week	21.6	0.5-40

imum weekly working time with CoCrMo alloys of 20 hours. In eight laboratories (out of 24) a total of 10 subjects met this criterion. Full shift air samples were collected and the dust levels were compared with the Swedish occupational exposure limit values for a full working day in effect at the time.<sup>19</sup>

Total dust was analysed gravimetrically while crystalline quartz, cristobalite, tridymite, and silicon carbide were determined by x ray diffraction. Cobalt, chromium, molybdenum, and aluminium were analysed with x ray fluorescence.

#### STATISTICAL ANALYSIS

Spirometric findings were analysed by the Student's *t* test for paired differences (observed minus expected values) and 95% confidence intervals (95% CI) for the mean difference. To examine simultaneously the impact of exposure and smoking multiple regression analyses were performed. The differences between observed and expected values were regressed on exposure (three classes from lowest to highest) and smoking (three classes). For the radiographs the level of interobserver agreement beyond chance was calculated as Cohen's kappa.<sup>20</sup>

### Results

#### MEDICAL SURVEY

Responses were received from 153 laboratories. Among the non-responders 11 were considered to be genuine and in eight cases the ques-

tionnaires were returned because of incorrect addresses. The response rate to the questionnaire from the laboratories was therefore 93%, and from 24 laboratories positive responses were received with names of 44 individuals who tentatively fulfilled the inclusion criteria. However, after checking the exposure history with the appointed technicians and their employers only 37 subjects (34 men) were included in the study (table 1).

The lung function of the dental technicians was significantly lower than expected for both VC and FEV<sub>1</sub> with a mean difference of observed to predicted values of approximately -0.3 l (table 2). The reduction in lung function was more pronounced in smokers than in non-smokers and ex-smokers.

A dose-response relation between exposure to CoCrMo dust in hours per week and reductions of both VC and FEV<sub>1</sub> was found (table 3). The relation also appeared when self estimated levels of dust exposure were taken into account. However, no such dose-response effects were noticed for total numbers of years of exposure to CoCrMo dust (data not shown). Similar findings were obtained when lung function was regressed with dust exposure and smoking.

There was an excellent overall agreement between the readers of the chest radiographs (Cohen's kappa = 0.78; table 4) who both found a small opacity profusion of ILO category 1 or higher (read as  $\geq 1/0$ ) in five exposed subjects. However, the readers disagreed in their classification of two exposed subjects, yielding a total of six radiologically positive cases. Both readers assessed all radiographs from the reference subjects as normal. The lung function of the six cases with radiological evidence of pneumoconiosis was not significantly different from the rest of the study group.

Table 2 Mean (SD) lung function (in litres) by smoking habits in dental technicians exposed to CoCrMo dust

	No.	Observed	Predicted	Mean difference (95% CI)	p value
Vital capacity					
All	37	4.92 (0.79)	5.26 (0.56)	-0.34 (-0.54 to -0.14)	<0.01
Smokers	12	4.52 (0.69)	5.01 (0.38)	-0.48 (-0.85 to -0.12)	<0.05
Ex-smokers	13	5.06 (0.89)	5.36 (0.62)	-0.30 (-0.75 to 0.14)	>0.05
Non-smokers	12	5.17 (0.68)	5.40 (0.60)	-0.23 (-0.53 to 0.07)	>0.05
FEV <sub>1</sub>					
All	37	3.67 (0.66)	3.99 (0.54)	-0.32 (-0.47 to -0.17)	<0.01
Smokers	12	3.30 (0.58)	3.70 (0.38)	-0.40 (-0.67 to -0.12)	<0.01
Ex-smokers	13	3.83 (0.80)	4.08 (0.57)	-0.26 (-0.60 to 0.09)	>0.05
Non-smokers	12	3.87 (0.43)	4.19 (0.54)	-0.32 (-0.53 to -0.12)	<0.01

FEV<sub>1</sub> = forced expiratory volume in one second.

Table 3 Lung function by occupational exposure to CoCrMo dust

Exposure	No.	Vital capacity		FEV <sub>1</sub>	
		Unadjusted difference (95% CI)	Adjusted difference (95% CI)	Unadjusted difference (95% CI)	Adjusted difference (95% CI)
Hours/week of work with CoCrMo					
≤9	12	-0.08 (-0.42 to 0.26)	-0.03 (-0.45 to 0.39)	-0.10 (-0.34 to 0.14)	-0.09 (-0.38 to 0.19)
10-39	11	-0.40 (-0.76 to -0.04)	-0.31 (-0.86 to 0.24)	-0.18 (-0.42 to 0.07)	-0.17 (-0.54 to 0.21)
40+	14	-0.50 (-0.82 to -0.18)	-0.44 (-0.88 to -0.01)	-0.61 (-0.83 to -0.39)	-0.61 (-0.91 to -0.31)
Self estimated dust exposure level					
Low	11	-0.21 (-0.56 to 0.15)	-0.18 (-0.67 to 0.32)	-0.17 (-0.43 to 0.10)	-0.23 (-0.60 to 0.14)
Medium	13	-0.17 (-0.49 to 0.16)	-0.15 (-0.54 to 0.25)	-0.23 (-0.48 to 0.02)	-0.27 (-0.57 to 0.03)
High	13	-0.62 (-0.94 to -0.29)	-0.57 (-1.09 to -0.05)	-0.53 (-0.78 to -0.28)	-0.59 (-0.98 to -0.20)

FEV<sub>1</sub> = forced expiratory volume in one second.

Difference of observed to expected value (litres) analysed by multiple regression analysis, with and without adjustment for smoking.



CoCrMo dust exposure in terms of the number of hours exposed per week and self-estimated exposure level. The absence of a negative trend for the number of years exposed was probably due to an inverse relation between the number of hours exposed per week and the number of years exposed. The reduction in ventilatory capacity could be interpreted as supporting the case observations of dental technician's pneumoconiosis and as being indicative of early lung fibrosis. However, the absence of a significant difference in lung function between cases of dental technician's pneumoconiosis and the remainder of the study group argues against this theory. Alternatively, the reduced lung function may indicate a component of bronchoconstriction representing a parallel phenomenon of cobalt-induced obstructive lung dysfunction.<sup>22</sup>

In the evaluation of the lung function data some factors which tend to exert a conservative influence on the outcome variables should be discussed. In particular, smoking habits were not taken into account in the reference material used to derive expected values.<sup>17</sup> The proportion of smokers among Swedish men aged 30–64 years was considerably higher (approximately 75%) in the mid 1950s<sup>23</sup> when the reference data were collected than the 32% noted in the present study. Accordingly, the reference data may be significantly influenced by smoking. This would tend to lower the expected values. Moreover, birth cohort effects – that is, new generations having better lung function than their ancestors<sup>24</sup> – would be expected, given the time span in data collection of almost three decades between the present study group and the reference material.

The number of dust samples in this study was limited. However, all samples obtained from dental laboratories with local exhaust ventilation indicate that the occupational exposure limits were well contained. In contrast, in laboratories without such equipment high levels were found, particularly of cobalt. In this respect our results are in accordance with those of Brune and Beltesbrekke<sup>25</sup> who found cobalt levels of 1.0–1.2 mg/m<sup>3</sup> in laboratories where exhaust ventilation was not used and <0.1 mg/m<sup>3</sup> with ventilation.

In conclusion, reduced lung function and pneumoconiosis are hazards which face dental technicians exposed to dust generated in the processing of CoCrMo alloys. For prevention, local exhaust ventilation should be encouraged.

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