# CHROMIUM AND COBALT LEVELS AMONG DENTAL TECHNICIANS IN THE NORTHERN JORDAN

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**Abstract**

**Introduction:** Dental technicians have higher occupational exposure to the heavy metals chromium and cobalt. Exposure to these metals is associated with many adverse health effects.

**Study objectives:** To determine the prevalence of chromium and cobalt toxicity among dental technicians, and to correlate the occupational exposure for chromium and cobalt with occupational diseases.

**Methods and subjects:**

**Study design and setting**: Descriptive cross-sectional study design was utilized. The present study was conducted in the Northern Jordan. A total of 100 laboratory technicians were included in this study.,. These involved dental laboratory technicians (n=50) as sample group, and medical laboratory technicians (n=50) as a control group. Data was collected by a prepared questionnaire composed of both demographical and occupational variables. Blood samples were collected from the participants and were analysed for concentrations of cobalt and chromium at Princess Haya Center for Biotechnology using atomic absorption spectrometry technique.

**Results:** The mean concentration of chromium was 46.18$\pm$58.20$\mu$g/dL for dental technicians and 17.84$\pm$43.46$\mu$g/dL for medical technicians. There was a significant relationship in the chromium exposure among dental technicians compared with medical technicians ($P < 0.05$). The mean concentration for cobalt was 2.23 $\pm$ 6.53 $\mu$g/dL, while it was 0.2$\pm$0.38$\mu$g/dL for medical technicians. The difference in cobalt concentrations between the sample and control group was statistically significant ($P < 0.05$). This study revealed that the prevalence of some diseases such as diabetes and epilepsy

do not associate with the occupational environment (dental or medical technicians), while other diseases such as bronchitis and allergy were prevalent a in dental technicians.

**Conclusions:** Ddental technicians have more blood concentrations of the heavy metals Cchromium and Ccobalt compared with medical technicians, which are attributed to the occupational exposure and environmental conditions in dental laboratories.

**Keywords:** Dental Technician, Heavy Metals, Toxicity, Jordan

**Introduction:**

The exposure of dental technicians to the constituents of dental materials may lead to occupational hazards. Dental technicians are exposed during daily duties to respirable metal fumes and grinding dust through the processing of cast dental restorations (Brune, 1980; Brune, 1980a; Brune, 1980b).

In a study conducted by Morgenroth and Kronenberger (1984), the results suggested that pneumoconiosis could be elicited by dust from the processing of dental materials. Previous study lacked a control group and did not count for confounding factors like smoking. However, dental laboratory technician's work involves a variety of potentially toxic substances, including non-precious metal alloys used in the manufacture of crowns, bridges, and dentures. Non-precious metal alloys used in dental laboratories contain chromium, cobalt and other elements such as molybdenum (William *et al.*, 1984).

An earlier study conducted by Kronenberger *et al.*, (1981) reported a clinical study of dental laboratory technicians from Germany. The sample included 250 dental technicians and 70 volunteers. They found that half of participants complained of respiratory symptoms; pneumoconiosis was noted on 27 chest radiographs. They also found that 21 had a fiberoptic bronchoscopy and interstitial fibrosis was noted in 12 biopsies; the lesions were topographically located near dust deposits.

Several reasons are beyond the utilization of cobalt and chrome in non-precious dental alloys. These reasons include availability and being inexpensive compared to conventional gold alloys. Furthermore, such alloys exhibit an inferior corrosion resistance (Reclaru et al., 2004).

Chromium exhibits several biological roles. Trivalent chromium is included as a nutritional constituent for a large group of organisms (Hogan and Michael, 2010). In addition, trace amounts of trivalent chromium affect sugar and lipid metabolism in human. Moreover, its deficiency is assumed to lead to a chromium deficiency (Mertz and Walter, 1993). Other chromium states as hexavalent chromium is proved to be very toxic and mutagenic

when inhaled. Moreover, other states have not been recognized as a carcinogen when in solution, even though it may cause allergic contact dermatitis (Tox FAQs, 2001).

It has been recommended to lower daily chromium intake in the United States from 50–200$\mu$g for an adult to 35$\mu$g (adult male) and to 25$\mu$g (adult female) (Vincent, 2007).

Cobalt is one of the essential elements in the body. It is required to form cobalamin, vitamin B12, a coenzyme for ...enzyme. Its deficiency causes anemia (Anjali et al., 2010). Vitamin B12 is essential for thymidine synthesis, and ultimately, DNA biosynthesis and the transcription process itself (Yukinori et al., 2001). Irrespective of the fact that cobalt is an essential element in little quantities, it has been estimated that soluble cobalt salts are toxic and the LD50 is in a range between 150 and 500 mg/kg (Donaldson, 2005).

Cobalt has been associated with contact dermatitis and is known as carcinogenic (Basketter et al., 2010). It has also been reported to cause beer-drinker's cardiomyopathy after the addition of cobalt to beer to stabilize the beer's foam (Donald, 1999).

**Study objectives:** The present study was conducted to achieve the following objectives:

(1) To estimate the toxic levels of cobalt and chromium among dental technicians.

(2) To correlate the clinical features of diseases related to occupational exposure as asthma, cardiovascular diseases with levels of cobalt and chromium among dental technicians.

**Methods and subjects**

**Study design:** A cross sectional study was disgned to collect data from all participants at the same time.

**Study setting:** The present study was conducted in the following places: Dental laboratories in Dental teaching Centre- Irbid, dental laboratories at Faculty of Dentistry atJordan University of Science and Technology, and several private dental laboratories in Irbid city.

**Study population**

The target population was all dental technicians in the North of Jordan. A convenient sample of 50 dental technicians was selected from dental laboratories. All dental technicians whom accepted to participate in the present study were included.

**Data collection**

Relevant data and blood samples were collected from both study and control groups after informed consent. The consent form was approved by the institutional review board at Jordan University of Science and Technology.

**Samples collection**

Questionnaires (appendix B) were filled by all participants. Blood samples were collected from all participants.

**Questionnaire**

The first part of the questionnaire determined the demographic data of the participants, which includes age, gender, smoking habits, type and place of occupation, and duration of employment. The second part covered the types of work, and the third part covered personal protective equipment such as mask, gloves and lab-coat, diseases such as sensitivity, urinary tract infection, and the perception of participants for occupational dangers associated with their job.

**Sample analysis of heavy metals**

The concentrations of heavy metals (chromium and cobalt) were analyzed by atomic absorption spectrophotometer (AAS), which allow for the measurement of a wide range of concentrations of metals in biological samples.

**Statistical analysis**

Collected data were analysed by Chi-Square test, frequency, percentage and *t*-test using statistical package for the social sciences SPSS (version 16, SPSS, an IBM Company, Chicago, USA). *P*-value of $\leq 0.05$ was considered statistically significant.

**Results**

**Demographic characteristics of participants**

The data presented in table 1 showed that 70% of dental technicians and 80% of medical laboratory technicians were Jordanians. All study participants were dental technicians and all control group participants were medical technologists (Table 1).

**Table 1:** Demographic Characteristics of participants

| VARIABLE | Dental technicians | | Medical laboratory technicians | |
|---|---|---|---|---|
| | Frequency (N) | Percentage (%) | Frequency (N) | Percentage (%) |
| **Nationality** | | | | |
| **Jordanian** | 35 | 70 | 40 | 80 |
| **Non-Jordanian** | 15 | 30 | 10 | 20 |
| **Job** | | | | |
| **Technicians** | 50 | 100 | 50 | 100 |
| **Non technicians** | 0 | 0 | 0 | 0 |

**Use of protection tools among dental technicians and medical technologists**

This study showed that the use of hearing protective tools to be more among dental technicians (32%) than medical technologists (2%). Protective coats were more used among medical technologist (88%) compared with

dental technicians (68%). Medical technologists reported more frequently wearing of gloves (88%) compared with dental technicians (56%). Protective shoes were shown to be more used by medical technologists (8%) compared with dental technicians (2%). Head cap was used more by dental technicians (20%) compared with medical technologists (8%). Welding eye glasses were also used more by dental technicians (28%), while only 2% of medical technologists admitted their use. More technicians (42%) reported using face masks compared with 4% of medical technologists (Table 2).

**Table 2:** The use of protective tools during working.

| VARIABLE | Dental technicians | | Medical technologist | |
|---|---|---|---|---|
| | **Frequency (N)** | **Percentage (%)** | **Frequency (N)** | **Percentage (%)** |
| **Hearing tools:** | | | | |
| -Yes | 16 | 32 | 1 | 2 |
| -No | 34 | 68 | 49 | 98 |
| **Protective coat:** | | | | |
| -Yes | 34 | 68 | 44 | 88 |
| -No | 16 | 32 | 6 | 12 |
| **Gloves:** | | | | |
| -Yes | 28 | 56 | 44 | 88 |
| -NO | 22 | 44 | 6 | 12 |
| **Glasses:** | | | | |
| -Yes | 25 | 50 | 14 | 28 |
| -No | 25 | 50 | 36 | 72 |
| **Shoes (protective):** | | | | |
| -Yes | 1 | 2 | 4 | 8 |
| -No | 49 | 98 | 46 | 92 |
| **Head cap:** | | | | |
| -Yes | 10 | 20 | 4 | 8 |
| -No | 40 | 62.7 | 46 | 92 |
| **Welding glass:** | | | | |
| -Yes | 14 | 28 | 1 | 2 |
| -No | 36 | 72 | 49 | 98 |
| **Face mask:** | | | | |
| -Yes | 21 | 42 | 2 | 4 |
| -NO | 29 | 58 | 48 | 96 |

## The exposure to work related risks

Work related risks were explored through reporting the exposure to several parameters. 64% percent of dental technicians reported their exposure to gases, while 52% of medical technologists were found to be

exposed to gases. The variations of exposure to gases were statistically significant (*P*-value = 0.002).

Furthermore, the results showed that dental technicians expose to higher levels of metal gases compared with medical technologist (*P*- value < 0.001). The results also revealed that dental technicians expose to the noise contamination in a higher manner than the medical technologist (P-value < 0.001). Cold/heat stress was found to be significantly higher among dental technicians compared with medical technologists (*P*< 0.001). Smoking variations were not statistically significant (*P* > 0.05) (Table 3).

**Table 3:** Work Related Risk Factors

| Variable | Dental technicians | | Medical technologist | | *P*-VALUE |
|---|---|---|---|---|---|
| | Frequency (N) | Percentage (%) | Frequency (N) | Percentage (%) | |
| **Gases and vapors:** | | | | | 0.002 |
| Yes | 32 | 64 | 26 | 52 | |
| -No - | 18 | 36 | 24 | 48 | |
| **Metal gases:** | | | | | <0.001 |
| -Yes | 33 | 92.2 | 9 | 18 | |
| -No | 17 | 7.8 | 41 | 82 | |
| **Cold/ heat:** | | | | | <0.00 |
| -Yes | 30 | 60 | 14 | 28 | |
| -No | 20 | 40 | 36 | 72 | |
| **Living closed to factory:** | | | | | >0.05 |
| -Yes | 2 | 4 | 1 | 2 | |
| -No | 48 | 96 | 49 | 98 | |
| **Smoking:** | | | | | >0.05 |
| -Yes | 12 | 24 | 10 | 20 | |
| -No | 38 | 76 | 4 | 84 | |

## General Health Status of Participants

This study indicated that 2% of medical technologists have epilepsy, whereas 4% of medical technologists have diabetes. Sensitivity was reported by 28% of dental technicians and 12% of medical technologists. The variation of sensitivity among dental technicians and medical technologists was not statistically significant (*P* >0.05).The incidence of asthma was shown to be the same (2%) among dental technicians and medical technologists. This variation was not statistically significant *P* >0.05). Bronchitis in dental technicians was 8%,while only half of this pecent were found in medical technologists. This variation is not statistically significant

(*P*>0.05). Tuberculosis was also reported by 2% of medical technologists. Hepatitis was reported by 12% of dental technicians (Table 4).

**Table 4:** Diseases experienced by study participants.

| DISEASE | Dental technicians | | Medical technologist | |
|---|---|---|---|---|
| | Frequency (N) | Percentage (%) | Frequency (N) | Percentage (%) |
| **Epilepsy:** | | | | |
| -Yes | 0 | 0 | 1 | 2 |
| -No | 50 | 100 | 49 | 98 |
| **Diabetes :** | | | | |
| -Yes | 0 | 0 | 2 | 4 |
| -No | 50 | 100 | 48 | 96 |
| **Sensitivity (contact):** | | | | |
| -Yes | 14 | 28 | 6 | 12 |
| -NO | 36 | 72 | 44 | 88 |
| **Asthma:** | | | | |
| -Yes | 1 | 2 | 1 | 2 |
| -No | 49 | 98 | 49 | 98 |
| **Bronchitis** | | | | |
| Yes - | 4 | 8 | 2 | 4 |
| No - | 46 | 92 | 48 | 96 |
| **Lung swelling** | | | | |
| Yes- | 0 | 0 | 1 | 2 |
| No - | 50 | 100 | 49 | 98 |
| **TB** | | | | |
| -Yes | 0 | 0 | 1 | 2 |
| -No | 50 | 100 | 49 | 98 |
| **Hepatitis** | | | | |
| -Yes | 6 | 12 | 0 | 0 |
| -No | 44 | 88 | 50 | 100 |

## Blood levels of Chromium and Cobalt

The results here showed that dental technicians have higher blood levels of chromium (M 46.18 $\mu$g/dL) compared with medical technologists (M 17.84 $\mu$g/dL). This variation is statistically significant (*P*= 0.03). The data form this experiment were also showed that there are significant variations in the cobalt level in dental technicians (2.23$\mu$g/dL) compared with its levels in medical technologists (0.20$\mu$g/dL). This variation is considered significant (*P* value = 0.01) (Table 5).

**Table 5:** The Level of Chromium and Cobalt among Dental technicians and Medical Technologists

| Heavy metal | Mean (ug/dl) | Standard deviation | P value |
|---|---|---|---|
| **Chromium-DT** | 46.18 | 58.20 | 0.003 |
| **Chromium-MT** | 17.84 | 43.46 | |
| **Cobalt-DT** | 2.23 | 6.53 | 0.01 |
| **Cobalt-MT** | 0.20 | 0.38 | |

## Discussion

The job nature of dental technicians exposes them to a risk of inhaling cobalt and chromium during casting and finishing processes in the production of skeletal prostheses on the daily bases (Mosconi *et al.*, 1994). The control group was selected among medical technologists whom have similar work conditions to dental technecions in terms of space as well as working conditions. Their data were also based on measurement the Co and Cr levels in blood.

Blood concentrations of Co and Cr clearly reflect recent exposure; this due to the fact that serum concentrations may fluctuate with emotional changes, the time of day, sample taken, or foods eaten prior taking the sample (Laker, 1982; Gerstenberger *et al*., 1997; Chowdhury *et al.*, 2000).

We also explored if dental technicians are more exposed to occupational hazards compared with medical technologists. The results showed that dental technicians are more exposed to gases compared with medical technologists, which seems statistically significant ($P$-value = 0.02). Actually, based on this finding, it can be concluded that working conditions lead to over exposure of dental technicians to the gases. Similarily,this is applied for other work risks factors including metal gases, noise contamination, and cold/heat stress conditions. In all cases, dental technicians are have higher exposure to adverse occupational conditions compared with medical technologists ($P$-value < 0.05, in all cases). Taken together, the previous conditions reflect various sources for direct contact with heavy metals during work. Two variables were found to be not varied among dental technicians and medical technologists, living close to the factory and smoking ($P$-value > 0.05, for both variables). It is obvious that both variables have similar impacts on participants, and their variation does not affect the exposure to chromium and cobalt.

The data in the present study showed that the mean concentration of chromium for dental technicians was higher than that of medical technologists. Similarly, the mean level of cobalt for dental technicians was higher than that for medical technologist . Such findings are due to the nature of the work and to the environment of laboratory. Dental technicians expose to heavy metal through inhalation and skin absorption when making dental prosthesis such as crown, bridge, and metallic removable partial denture

framework; in addition, the environment of dental laboratory may have airborne contamination from dust and metals. The result of this study are in line with the findings of Afridi *et al.* (2006), which indicate a correlation of heavy metals in biological samples (blood, urine and hair) with respect to the duration of exposure time among workers of steel mill.

**Conclusions**

The results from this study suggested a significant exposure for the heavy metals chromium and cobalt among dental technicians compared with medical technicians. The prevelance of the degenegrative diseases such as epilepsy and diabetes were found to be more higher among medical technologist compared to dental technicians, indicating that such diseases may not attribute to the occupational risks.In contrast, diseases like bronchitis and allergy exhibited an occupational nature and were linked with dental technicians more than medical technologists.

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