JBR Journal of Interdisciplinary Medicine and Dental Science

Al-Awadeen et al., J Interdiscipl Med Dent Sci 2014, 2:5
DOI: 10.4172/2376-032X.1000138

Research Article Open Access

Determination of Selected Heavy Metal Levels in Scalp Hair and Fingernail Samples from Dental Laboratory Technicians

Mervat A. Al-Awadeen[1], Ahmad S Al-Hiyasat[2]*, Adnan M. Massadeh[3] and Yousef S. Khader[1]

[1]*Department of Public health, Community Medicine and Family Medicine, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan*
[2]*Department of Conservative Dentistry, Faculty of Dentistry, Jordan University of Science and Technology, Irbid, Jordan*
[3]*Department of Medicinal Chemistry and Pharmacognosy, Faculty of Pharmacy, Jordan University of Science and Technology, Irbid, Jordan*

Abstract

The aim of this study was to determine selected heavy metal levels including cobalt (Co), Chromium (Cr) nickel (Ni) in scalp hair and fingernail samples of dental technicians. The scalp hair and fingernail samples were collected from 55 dental technicians and 25 medical technicians (control group). In the same time a questionnaire was filled by each subject of the two groups. The concentration of heavy metals (Co, Cr and Ni) in scalp hair and fingernail were determined by spectrometry. The result showed that the Co concentration in hair and nails of dental technicians was (0.74 µg/g, 6.5 µg/g respectively) compared with medical technicians (0.04 µg/g, 0.03 µg/g respectively). Ni concentration in hair and nails of dental technicians was (12.00 µg/g, 17.4 µg/g respectively) compared with medical technicians (6.3 µg/g, 6.00 µg/g respectively). Concentration of Cr in hair and nails of dental technicians was (9.37 µg/g, 10.6 µg/g respectively) compared with medical technicians (0.0 µg/g, 10.3 µg/g respectively), Ni was found to have the highest level in the hair and fingernails of dental technicians.

Keywords: Heavy metals; Dental technician; Scalp hair; Fingernails

Introduction

Dental laboratory technicians have multiple occupational exposures, which may have adverse effects on their health. The potential occupational risk factors include chemical, physical, psychological, ergonomic, and other job-related factors [1,2].

The substances to which dental technicians are exposed include heavy metals from the base metal alloys and some other materials that are used in the fabrication of dental prosthesis [3]. Indeed, base metal alloys have become widely used in dental practice as cast materials and especially used for the construction of metal core in metal-ceramic restorations and the construction of Co-Cr metal framework of removable partial denture (RPD) (cobalt-chromium) [4-6]. In general, these alloys consist of 35–65% cobalt (Co), 20–30% chromium (Cr), 0–30% nickel (Ni) and small amounts of molybdenum (Mo), silica, beryllium, boron and carbon [7,8].

Nickel (Ni), chromium (Cr) and cobalt (Co) are essential elements required for the human body in extremely low amounts; whereas at high levels these elements may cause serious problems in the body [9]. Contact with Ni compounds can cause a variety of adverse effects on human health, such as nickel allergy in the form of contact dermatitis, lung fibrosis, cardiovascular and kidney diseases and cancer of the respiratory tract [10,11]. Chromium may cause asthma, cough, shortness of breath, and wheezing [12]. Occupational exposure to Co is primarily via inhalation of dusts, fumes, or mists containing Co, targeting the skin and the respiratory tract [13].

The use of scalp hair and fingernails samples in an assessment of environmental and occupational metal exposure has received a great deal of attention in the literature [14-19]. In the past few years human hair and fingernails have been recognised as an invaluable tissue and more attractive diagnostic tool in assessing heavy metals in human body with environmental exposure [20]. Nowadays there is an increasing interest of scalp hair and fingernails in the fields of medical, biological, forensic, and environmental sciences [17,18,21-23], they can be easily sampled collected, stored and prepared for analysis [24,25].

The hypothesis of the present study is that the dental laboratory technicians are at risk of exposure to heavy metals from the alloys that they used in the production of dental prosthesis, thus the level of heavy metals in their body will be increased than the normal level in the general population, their hair and figure nails are good biological tissues to trace the level of these elements in their body. Therefore, In this study, the levels of heavy metals namely: Co, Cr and Ni in scalp hair and fingernails samples collected from dental technicians were determined and compared with the other samples collected from medical laboratory works as a control group.

Materials and Methods

Study population

This study was conducted for determination of selected heavy metal levels in scalp hair and fingernail samples collected from dental technicians in Jordan. The target population was dental technicians who work in the dental laboratories in Jordan. A convenient sample of 21 dental laboratories and 6 medical laboratories were selected from those available in the north and middle region of Jordan.

Samples collection

A total of 80 samples of human hair and 80 samples of fingernails were collected from 55 dental technicians who work in dental laboratories and 25 medical laboratories technicians as a control group. The age range for all of the subjects was 20-50 years old with a mean of 36 years. At the begging all subjects were given a form detailing the aim of the study and all agreed to participants and signed this form.

A questionnaire was also administered in order to collect details

***Corresponding author:** Professor Ahmad S. Al-Hiyasat, Department of Conservative Dentistry, Faculty of Dentistry, Jordan University of Science and Technology, Irbid, Jordan, Tel.: +962 7 97066097; Fax: + 962 2 7201080; E-mail: hiyasat@just.edu.jo

Received: July 30, 2014; **Accepted:** August 04, 2014; **Published:** August 11, 2014

Citation: Al-Awadeen MA, Al-Hiyasat AS, Massadeh AM, Khader YS (2014) Determination of Selected Heavy Metal Levels in Scalp Hair and Fingernail Samples from Dental Laboratory Technicians. J Interdiscipl Med Dent Sci 2: 138. doi: 10.4172/2376-032X.1000138

concerning demographic data of the participants under this study includes age, gender, smoking habits, type and place of occupation, and duration of employment. The second part of the questions include working time in hours/week with alloys contain heavy metals (Co, Cr and Ni), laboratory type (government, private), and use of personal protective equipment such as mask, gloves and lab-coat.

Chemical reagents

All chemicals and reagents used in analysis were analytical grade, HNO_3 65-68% (Scharlau, Scharlau Chemie S.A, Barcelona, Spain), and H_2O_2 35% w/w extra pure (Scharlau, Scharlau Chemie S.A, Barcelona, Spain). Washing reagents, diethyl ether; $C_4H_{10}O$ (M-TEAIA, Ohio, USA), and acetone; C_3H_6O 99.5%, (Panreac, Panreac Quimica S.A.U, Barcelona, Spain).

All glassware used in this study were cleaned with soap, washed thoroughly with tap water, rinsed with distilled water, and soaked in 10% HNO_3 for 24 h to remove any contamination by heavy metals; then the glassware were washed thoroughly with deiozised water.

Preparation of scalp hair and fingernails samples

Preparation of the samples for analysis was carried out based on standard methods that recommended by other researchers with some modifications [26,27].

Preparation of hair samples: Hair samples were collected and cut into very small pieces with stainless steel scissors, and soaked in a mixture solution with a ratio of 3: 1: 20 (v/v) of diethyl ether, acetone and deionized water for 1 h with use of ultrasonic bath, and then rinsed thoroughly with deionized water. After that, the hair samples were placed in glass petri-dishes, and then dried at 105°C for 24 h in an oven (Model D4C Genlab, Widnes, England). Then the following steps were carried out as follows: i) A weight of 1 g hair samples were placed in a porcelain evaporating dish; ii) The hair samples were digested with a mixture of HNO_3 and H_2O_2 with a ratio of 6:2 (v/v) in a the porcelain evaporating dish; iii) The digested samples was then heated on a hot plate at 80°C to near dryness; iv) An aliquot 10 ml of 0.1M HNO_3 was added to each digested sample; v) The extract was filtered via Whatman filter paper No. 42 (Springfield Mill, Maidstone, Kent, England), then was kept in a 10 ml polyethylene flask (Arab Medical Containers, Sahab, Amman) at 4°C until analysis.

Preparation of nail samples: The same procedure used for scalp hair in the above mentioned section is used for nail samples. Except, the ratio (v/v) of diethyl ether, acetone and deionized water was 3:2:5. Also, the weight of nail samples was ranged between (0.1-0.5) g. The same steps in scalp hair samples mentioned (i-v) in above were carried out for nail samples, the digested ratio of HNO_3 and H_2O_2 was of 3:1 (v/v).

Measurement and instrumentation

The concentrations of heavy metals (Co, Cr and Ni) were analyzed by atomic absorption spectrophotometer (AAS). F-AAS (Shimadzu, AA-6300, Tokyo, JAPAN) fully equipped for flame (air acetylene) was used to determine the concentration of Ni with a detection limit of 0.01 ppm, whereas GFA-AAS (Shimadzu, EX7, Tokyo, JAPAN) was used for analysis of Co and Cr with a detection limit of 5 ppb. The wavelength used for Co, Cr and Ni were 240.7, 357.9 and 282 nm, respectively. The parameters of the mechanics used for analysis of three metals investigated are shown in Table 1.

Calibration curves were constructed by diluting a series of standard solutions of each element to achieve a linear dynamic range for each under test element. The dynamic linear ranges for Co, Cr and Ni, are ranged between (0-15) µg/L, (0-20) µg/L and (0-2) mg/L, respectively.

Parameters	Co	Cr	Ni
Lamp Current(mA)	20	10	12
Wave length (nm)	240.7	357.9	282
Slite –width (nm)	0.2	0.7	0.2
Background correction	D_2 lamp	D_2 lamp	D_2 lamp
Sample volume	(10)µL	(20)µL	3ml
Detection limit	5ppb	5ppb	0.01ppm

Table 1: Measurement Conditions for GF-AAS and F-AAS used in analysis.

Validation of method

Quality control was used to validate the accuracy of the method using different standard with known concentration of Co (100 ppb), Cr (125 ppb) and Ni (120 ppm). The result achieved was (94.3 ppb, 121.6 ppb and 114.8 ppm for Co, Cr and Ni, respectively). Thus % accuracy obtained was: 94.3%, 97.3% and 95.7% for Co, Cr and Ni, respectively. This indicates that there was a good agreement between the true and measured values for these elements.

Statistical analysis

The data obtained from analysis the hair and fingernails of the subject investigated in this study regarding the concentration of the heavy metals and the associated factors demographically and environment of work were analyzed statistically by multivariable analysis and Mann–Whitney test using statistical package for the social sciences SPSS.

p-value of ≤ 0.05 was considered statistically significant in the result presented of the study.

Results

Table 2 represents the personal data of 55 dental technicians and 25 medical technicians as a control group are presented. Almost half of participants aged between 21- 30 years. The majority of medical technicians and 36.4% of dental technicians participated in this study were working in governmental sector. All medical technicians and the majority of dental technicians reported wearing lab coat and dental technicians were less likely to use gloves.

Overall the concentration of heavy metals in hair of dental technicians was significantly more than in the hair of medical technicians (Figure 1) for Co, Cr and Ni (Mann-W test, $p<0.001$, $p<0.001$, $p=0.001$ respectively) . In both groups Ni was the highest values, Co was found far much less than Ni as well as than Cr in the dental technicians while in the medical technicians no Cr at all was detected**.** Analysis of multivariable (Table 3) indicated that only the Ni concentration in the hair of dental technicians was significantly affected by; the age of subjects, smoking of the Sheesha, place of work, working time and use of the suction by the technicians. While the gender, smoking habits, duration of employment (years) and the use of mask have no significant effect on the concentration of Ni. For Co and Cr only the Co concentration was found to be significantly affected by the place of the work where the other variables have no significant effect at all in the concentration of Co nor the Cr. Table 4, showed that Ni concentration in hair of medical technicians was significantly affected by the variables of age, gender and duration of employment.

Variable	Dental technician *n (%)	Medical technician n (%)	P- value
Age (years) 21-30 31-50	 28 (50.9) 27 (49.1)	 12 (48.0) 13 (52.0)	0.809
Gender Male Female	 40 (72.7) 15 (27.3)	 14 (56.0) 11 (44.0)	0.139
Smoking habit Smoker Non smoker	 25 (45.5) 30 (54.5)	 7 (28.0) 18 (72.0)	0.140
Sheesha (water pipe) Yes No	 11 (20.0) 44 (80.0)	 2 (8.0) 23 (92.0)	0.177
Place of work Private Governmental	 35 (63.6) 20 (36.4)	 3 (12.0) 22 (88.0)	**<0.001**
Duration of employment(years) Less than 5 years 6-10 years >10 years	 20 (36.4) 13 (23.6) 22 (40.0)	 12 (48.0) 4 (16.0) 9 (36.0)	0.575
Use of mask Yes No	 26 (47.3) 29 (52.7)	 1 (4.0) 24 (96.0)	**<0.001**
Use of gloves Yes No	 16 (29.1) 39 (70.9)	 20 (80.0) 5 (20.0)	**<0.001**
Wearing lab-coat Yes No	 43 (78.2) 12 (21.81)	 25 (100.0) 0 (0.0)	**0.011**

(Dental technician n=55, Medical technician=25)
*n: Number of samples

Table 2: Demographic and work related characteristics of the participants.

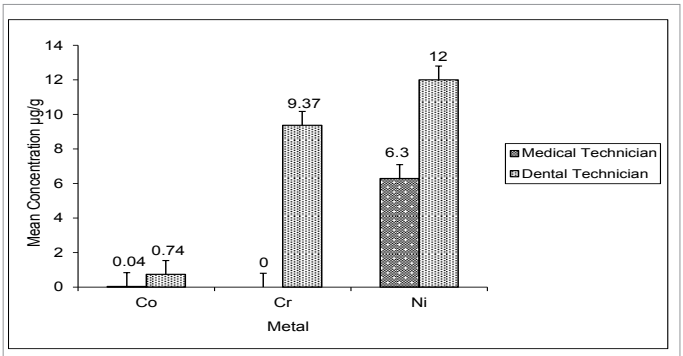

Figure 1: Mean concentrations of Co, Cr and Ni (µg/g) in hair of the dental technician and medical technicians.

While the other variables have no significant effect in the Ni. Co and Cr concentration have no significance at all in their concentrations related to the variables of the subjects investigated.

Figure 2 show the mean concentrations of Co, Cr and Ni (µg/g) in fingernails of the dental technician and medical technicians. The statistical analysis by Mann-Whitney revealed that the concentrations of both Ni and Co were significantly more in nails of dental technicians compared to their concentration in nails of the medical technicians (p<0.001), while the concentration of Cr was not significantly difference in fact the mean was very closed in both groups (p=0.196). Analysis of multivariable showed no signified effects at all for the variables investigated in the concentrations of heavy metal in the nails of dental technicians (Table 5). For the medical technicians samples analysis (Table 6), Co concentration was the only one that was significantly affected by the smoking habit, while the other variables had no significant effect in the Co, Ni and Cr concentration also were not significantly affected by any of the variables of the subjects investigated (p>0.05).

Correlation between the concentration of heavy metals in hair and nails (Table 7) indicated that all the metals investigated were significantly correlated to each other in hair as well as in fingernails. In the other hand the correlation in the concentration of the heavy metals in hair vs. nails was found to be significantly only for the Co (p<0.01) but not for Cr nor for Ni (p>0.05).

Discussion

In this study, concentration of Co, Cr and Ni were investigated in hair and fingernails of dental technicians. Dental technicians have a high

Variable	Mean concentration (S.D) (µg/g) in hair sample		
	Co	Cr	Ni
Age (years) 20-30 31-50 *p*-value	 0.7 ± 0.9 0.8 ± 0.6 0.752	 8.3 ± 6.6 10.5 ± 6.5 0.279	 11.9 ± 12.3 12.1 ± 10.8 **0.016**
Gender Male Female *p*-value	 0.8 ± 0.7 0.6 ± 0.8 0.537	 10.6 ± 6.8 6.1 ± 4.4 0.631	 11.5 ± 9.6 13.4 ± 15.8 0.805
Smoking habit Smoker Non smoker *p*-value	 0.6 ± 0.5 0.8 ± 0.9 0.664	 9.9 ± 6.5 8.9 ± 6.7 0.284	 10.5 ± 10.0 13.3 ± 12.6 0.786
Sheesha(water pipe) Yes No *p*-value	 0.8 ± 0.7 0.7 ± 0.8 0.517	 11.3 ± 8.1 8.9 ± 6.1 0.165	 14.5 ± 13.5 11.4 ± 11.0 **0.035**
Place of work Private Government *p*-value	 0.9 ± 0.8 0.4 ± 0.4 **0.007**	 10.6 ± 6.6 7.2 ± 6.1 0.086	 13.4 ± 11.2 9.6 ± 11.8 **0.029**
Duration of employment(years) Less than 5 years 6-10 years >10 years *p*-value	 0.8 ± 1.1 0.6 ± 0.4 0.8 ± 0.6 0.834	 8.1 ± 6.9 9.1 ± 5.8 10.8 ± 6.6 0.688	 9.5 ± 10.5 14.8 ± 12.8 12.6 ± 11.7 0.172
Working time with heavy metal(h/w) 20-25 h >25 h *p*-value	 0.9 ± 0.8 0.6 ± 0.7 0.602	 11.1 ± 7.5 8.2 ± 5.3 0.083	 11.3 ± 8.2 12.9 ± 13.9 **0.002**
Personal suction system Yes No *p*-value	 0.80 ± 0.8 0.7 ± 0.7 0.544	 10.2 ± 7.0 8.4 ± 5.9 0.205	 12.8 ±12.9 11.0 ± 9.6 **0.001**
Use of mask Yes No *p*-value	 0.8 ± 0.8 0.7 ± 0.7 0.823	 9.6 ± 7.4 9.2 ± 5.8 0.989	 10.5 ± 8.9 13.4 ± 13.4 0.106
Use of gloves Yes No *p*-value	 0.6 ± 0.7 0.8 ± 0.8 0.342	 8.1 ± 6.9 9.9 ± 6.4 0.394	 10.7 ± 13.2 12.5 ± 10.8 0.151
Wearing lab-coat Yes No *p*-value	 0.8 ± 0.9 0.7 ± 0.3 0.838	 8.9 ± 6.9 11.2 ± 4.8 0.221	 11.8 ± 11.5 12.7 ± 11.8 0.582
Laboratory area available ≤140 m^2 >140 m^2 *p*-value	 0.8 ± 0.8 0.6 ± 0.6 0.568	 9.8 ± 6.7 8.6 ± 6.3 0.624	 12.3 ± 10.7 11.5 ± 13.0 0.220

Table 3: The multivariable analysis of the differences in the concentration of Co, Cr and Ni µg/g in hair among dental technicians.

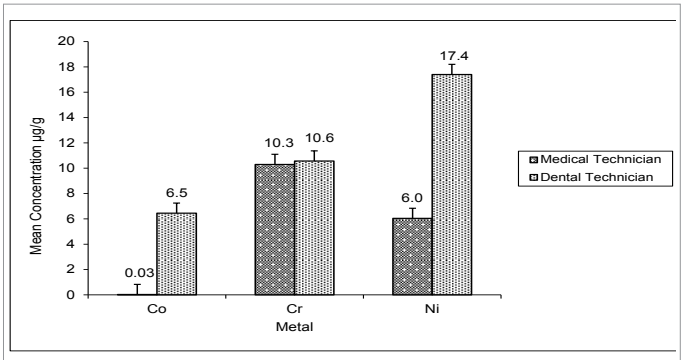

Figure 2: Mean concentrations of Co, Cr and Ni (µg/g) in fingernails of the dental technician and medical technicians.

Variable	Mean concentration (S.D) (µg/g) in hair sample Co	Cr	Ni
Age (years) 20-30 31-50 *p*-value	 0.03 ± 0.1 0.04 ± 0.06 0.771	 *ND	 1.6 ± 2.2 10.6 ± 12.3 **0.021**
Gender Male Female *p*-value	 0.02 ± 0.9 0.04 ± 0.06 0.530	 ND	 1.8 ± 2.8 12.1 ± 12.7 **0.007**
Smoking habit Smoker Non smoker *p*-value	 0.05 ± 0.13 0.02 ± 0.05 0.547	 ND	 1.4 ± 1.2 8.2 ± 11.2 0.124
Sheesha(water pipe) Yes No *p*-value	 0.0 ± 0.0 0.03 ± 0.08 0.540	 ND	 5.9 ± 7.1 6.3 ± 10.3 0.961
Place of work Private Government *p*-value	 0.1 ± 0.2 0.02 ± 0.04 0.058	 ND	 8.0 ± 12.9 6.1 ± 9.8 0.759
Duration of employment(years) Less than 5 years 6-10 years >10 years *p*-value	 0.04 ± 0.1 0.03 ± 0.04 0.02 ± 0.04 0.818	 ND	 2.1 ± 3.2 16.6 ± 18.1 7.3 ± 8.9 **0.032**
Use of mask Yes No *p*-value	 0.0 ± 0.0 0.03 ± 0.08 0.672	 ND	 11.0 ± 0.0 6.1 ± 10.1 0.639
Use of gloves Yes No *p*-value	 0.02 ± 0.05 0.08 ± 0.15 0.319	 ND	 6.6 ± 10.2 5.2 ± 9.9 0.434
Laboratory area available ≤140 m^2 >140 m^2 *p*-value	 0.08 ± 0.09 0.03 ± 0.08 0.138	 ND	 7.9 ± 9.7 5.9 ± 10.1 0.970

*ND: Not detected

Table 4: The multivariable analysis of the differences in the concentration of Co, Cr and Ni µg/g in hair among medical technicians.

mean concentration of Co, Cr and Ni (0.74 µg/g, 9.37 µg/g, and 12.0 µg/g respectively) in hair samples compared with medical technicians (0.04 µg/g, 0.0 µg/g, and 6.3 µg/g respectively), the difference was significant for the three heavy metals Co, Cr and Ni ($p<0.001$, $p<0.001$, $p=0.001$ respectively). The explanation of these differences is due to nature of work and environment of laboratory; dental technicians exposed to heavy metal through inhalation and skin absorption by production of dental prosthesis such as crown, bridge and the metal framework of removable partial denture, the environment of dental laboratory may have also airborne contamination from dust and metal [3,7,8].

Concentration of Ni in hair of dental technicians was found high than Co and Cr, this could be related to the base metal alloys that are the most frequently used in dental laboratories in Jordan that were found to be; Remanium CS (Ni 61%, Cr 26%, Mo 11%, Si 1.5%, Fe, Ce, Al, Co<1%), Heranium NA (Ni 59%, Cr 24%, Mo 10%,Fe, Mn, Ta, Si, No < 2%), Wiron 99 (Ni 65%, Cr 22.5%, Mo 10%,No 1%, Si 1%, Fe 0.5%, Ce 0.5%, C 0.02%), CB Soft (Ni 72.8%, Cr 4.9%, Cu 12.3%, other 10%) [28,29]. Thus, it could be seen that Ni represents approximately 60% or more of the composition of these alloys, whereas, the other elements were less than Ni content.

Variable	*Mean concentration (S.D) (µg/g) in nails sample* *Co*	*Cr*	*Ni*
Age (years) 20-30 31-50 p-value	 6.2 ± 6.5 6.8 ± 7.5 0.176	 19.3 ± 14.5 15.5 ± 10.8 0.954	 10.8 ± 7.4 10.4 ± 5.6 0.805
Gender Male Female p-value	 7.1 ± 7.6 4.7 ± 4.4 0.329	 18.5 ± 14.0 14.6 ± 8.4 0.879	 10.7 ± 6.3 10.2 ± 7.3 0.962
Smoking habit Smoker Non smoker p-value	 5.1 ± 5.5 7.6 ± 7.8 0.181	 18.2 ± 14.9 16.8 ± 10.9 0.851	 8.9 ± 4.9 11.9 ± 7.3 0.822
Sheesha(water pipe) Yes No p-value	 10.6 ± 8.9 5.4 ± 5.9 0.269	 20.3 ± 13.8 16.7 ± 12.6 0.747	 12.9 ± 8.4 9.9 ± 5.9 0.344
Place of work Private Government p-value	 7.2 ± 7.4 5.2 ± 6.0 0.263	 18.8 ± 13.6 15.0 ± 11.2 0.354	 11.2 ± 6.9 9.9 ± 5.8 0.382
Duration of employment(years Less than 5 years 6-10 years >10 years p-value	 7.7 ± 8.3 6.6 ± 7.3 5.3 ± 5.3 0.328	 20.2 ± 13.9 20.6 ± 16.1 13.1 ± 7.9 0.944	 12.2 ± 7.8 9.7 ± 6.2 9.6 ± 5.3 0.372
Working time with heavy metals(h/w) 20-25 h >25 h p-value	 5.9 ± 7.0 7.1 ± 6.9 0.460	 14.9 ±9.2 19.8 ± 15.2 0.627	 10.5 ± 7.3 10.7 ± 5.9 0.851
Personal suction system Yes No p-value	 5.6 ± 6.1 7.5 ± 7.8 0.501	 15.4 ± 8.4 19.8 ± 16.5 0.676	 11.4 ± 6.6 9.6 ± 6.4 0.787
Use of mask Yes No p-value	 6.4 ± 6.4 6.5 ± 7.5 0.527	 15.9 ± 10.9 18.7 ± 14.3 0.831	 12.0 ± 6.8 9.3 ± 6.0 0.308
Use of gloves Yes No p-value	 5.4 ± 5.5 6.9 ± 7.5 0.795	 15.7 ± 13.2 18.1 ± 12.7 0.340	 11.0 ± 7.7 10.3 ± 6.1 0.767
Wearing lab-coat Yes No p-value	 7.1 ± 7.4 4.3 ± 4.1 0.403	 17.9 ± 12.2 15.8 ± 15.1 0.154	 11.5 ± 6.9 7.3 ± 2.9 0.087
Laboratory area available ≤140 m^2 >140 m^2 p-value	 7.2 ± 7.5 5.2 ± 5.7 0.354	 17.9 ± 13.4 16.7 ± 11.9 0.986	 9.8 ± 5.6 11.8 ± 7.9 0.484

Table 5: The multivariable analysis of the differences in the concentration of Co, Cr and Ni µg/g in fingernails among dental technicians.

Variable	Mean concentration (S.D)(µg/g) in nails sample Co	Cr	Ni
Age (years)			
20-30	0.06 ± 0.16	13.3 ± 14.2	5.1 ± 11.2
31-50	0.01 ± 0.04	7.6 ± 3.9	6.9 ± 7.2
p-value	0.239	0.176	0.647
Gender			
Male	0.06 ± 0.15	10.2 ± 11.5	8.6 ± 11.3
Female	0.0 ± 0.0	0.5 ± 9.3	2.8 ± 3.9
p-value	0.149	0.927	0.119
Smoking habit			
Smoker	0.1 ± 0.2	10.2 ± 14.2	11.7 ± 13.9
Non smoker	0.0 ± 0.0	10.4 ± 9.0	3.9 ± 5.7
p-value	0.005	0.963	0.054
Sheesha(water pipe)			
Yes	0.0 ± 0.0	3.0 ± 2.2	10.9 ± 10.8
No	0.04 ± 0.1	10.9 ± 10.6	5.6 ± 9.1
p-value	0.638	0.312	0.453
Place of work			
Private	0.05 ± 0.08	5.8 ± 2.7	9.7 ± 7.1
Government	0.03 ± 0.1	10.9 ± 10.9	5.5 ± 9.4
p-value	0.300	0.558	0.304
Duration of employment(years)			
Less than 5 years	0.06 ± 0.02	13.1 ± 14.2	5.4 ± 1.9
6-10 years	0.0 ± 0.0	10.1 ± 5.6	0.9 ± 1.9
>10 years	0.01 ± 0.05	6.7 ± 2.7	9.1 ± 7.6
p-value	0.495	0.385	0.330
Use of mask			
Yes	0.0 ± 0.0	4.6 ± 0.0	18.5 ± 0.0
No	0.04 ± 0.1	10.6 ± 10.6	5.5 ± 9.0
p-value	0.745	0.584	0.172
Use of gloves			
Yes	0.04 ± 0.3	10.8 ± 11.3	5.3 ± 9.6
No	0.03 ± 0.06	8.6 ± 6.3	8.8 ± 7.4
p-value	0.630	0.946	0.366
laboratory area available			
≤140 m^2	0.04 ± 0.08	5.1 ± 3.1	4.9 ± 6.2
>140 m^2	0.04 ± 1.3	11.3 ± 11.0	6.3 ± 9.7
p-value	0.470	0.236	0.939

Table 6: The multivariable analysis of the differences in the concentration of Co, Cr and Ni µg/g in fingernails among medical technician.

	Human hair	Fingernails
Co vs. Cr	0.816**	0.315**
Co vs. Ni	0.297**	0.550*
Cr vs. Ni	0.376**	0.235*

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Table 7: Correlation between concentrations of selected heavy metals in human hair and fingernails.

Previous researcher have reported that the concentrations of Cr, Co and Ni in the urine of dental technicians were significantly elevated, confirming the occupational exposure effect to these metals, Co concentration was higher than the level of Cr and Ni [3], the alloys used in those laboratories that were investigated in (Ankara) were; Wironit (Co 64%, Cr 28%, Mo 5.0%), Remanium CD (Co 65%, Cr 26%, Mo 4.5%), Remanium GM380 (Co 64.5%, Cr 29%, Mo 4.5%), and also Formalloy C (Cr 30%, Ni 60%, Mo 5.0%), Ceraplus S (Cr 23%, Ni 62%, Mo 10%) and Remanium CS (Cr 26%, Ni 61%, Mo 11%). This may explain why the Co level was higher than Cr and Ni, since Co represents approximately more than 60% of the composition of three out of the six alloys that are used in the laboratory investigated.

In this study, there is a significant association between age of participates and Ni concentration for dental technicians and medical technicians (p<0.016, p<0.021 respectively). It is more in the age group 31-50 years old compared with 20-30 and this related to the number of years of exposure to the Ni during their work, this is also been shown to the association of working time with the concentration of the Ni level on the hair of the subjects.

The results in this study related to Ni levels in smoker (Sheesha) compared with non smoker are in a good agreement with other findings by Wolfsperger et al. [30], which could be related to the smoke that is inhaled from the Sheesha.

Furthermore, the place of work had a significant association with Co and Ni (p<0.007, p<0.029 respectively) and that is due to the absence of a exhaust in most laboratories and ventilation system in workplaces. Ni and Co were found in lower a concentration in governmental laboratories than private laboratories this due to more ventilated and more spacious space in governmental laboratories than the private one, also vacuum was noticed to be more used in the government laboratories than private.

For the medical technicians it was observed that gender is significantly associated with Ni concentration (p<0.007). Ni concentration was greater in female than those in male, possibly due to a more frequent contact with Ni- containing item: jewellery, buttons, accessories, certain shampoos, detergents, pigments, cosmetic etc., and use of cooking utensils [31].

The mean concentrations for three heavy metals (Co, Cr and Ni) found in fingernails of dental technicians was more than found in medical technicians with a significant level of Co and Ni (p<0.001, p<0.001 respectively). Moreover, the concentration of Ni in fingernails was the highest mean concentration compared Co and Cr means concentration for dental technicians. Gammelgaard and Veien [32] indicated that the main factors that affect the Ni level in fingernails are the duration and intensity of exposure, which in turn, depend on Ni content in the environment and its physicochemical state. The mean concentration of Cr in dental technicians and medical technicians were approximately similar (10.6 µg/g, 10.3 µg/g respectively) and there was no significant between the two groups this may due to the use of nail varnish by female in both groups involved in this study. Since it was not the case in the hair of medical technicians.

Although, the weight of the fingernail samples was much less than the hair sample, it was easier and more detectable to trace the concentration of the heavy metal investigated on the fingernail samples than in hair samples in both groups (dental technicians and medical technicians). Indeed, the concentration of the heavy metals of the three element investigated were relatively higher in fingernail samples than the hair samples. Nowak and Chmielnicka (2002) reported that metal contents in nails is higher relative to hair for all eight metals (Pb, Cd, Cu, Fe, Ni and Cr) that they investigated however, a unified relationship could not be established between the elemental composition of hair and nails. The different treatment, adopted by the subjects for washing the hair, affects the metal profile in hair as compared to nail samples. This is because few metals can be easily washed out of hair during treatment, which may lead to low levels of concentration in hair. Also biological nature of the nail compared to the hair may have an influence on metal concentration. Sukumar and Subramanian [27] reported that the high levels of elements observed in nails due to the nail samples are recommended as best indicator showing maximum levels because of high bioaccumulation, and external contamination.

For medical technicians, there was a significant difference between Co concentration in smoker and non smoker (p<0.005), our results are in a good agreement with other findings by Gennart et al. [33]

who reported that the mean value of individual sister chromatid exchange (SCE) frequencies and the percentage of high-frequency cells (HFC) were significantly higher compared to controls, and both were statistically significantly affected by exposure status and smoking habit. Moreover, Shirakawa and Morimoto [34] reported that the relationship between smoking habits and hard metal exposure in the elevation of specific immunoglobulin E (IgE) to cobalt remains unidentified.

In this study, it was found that the heavy metals (Co, Cr and Ni) are correlated to each other in hair and fingernail samples Table 7 whereas, there was no correlation between the concentration of Ni and Cr in hair vs. nails, but significant correlation was found for Co as shown in (Table 7). Other researchers reported that there was no correlation between nails vs. hair for the levels of Ni [32], and no correlation for other metals including Co and Cr in hair and nails samples [35].

In this study, it was clearly that there was a variation in number of dental technicians who had high concentrations of Co, Cr and Ni compared to the control group (medical technicians). This variation may be due to the nature of work and laboratory environment as mentioned previously.

A standard reference values for Co, Cr and Ni in human hair were; Co (0.01-0.2), Cr (0.10-1.50) and Ni (<1.40) μg/g [36]. Thus, Ni was the dominant element that affected the subjects investigated in this study in both groups dental technicians and medical technicians (87.3% vs. 52%) while Cr was the second having (78.2%) of the dental technicians above the standard reference while non was found for medical technicians, for the Co (65.5%) of the dental technicians had concentration higher than standard compared to (4%) among the medical technicians. This clearly demonstrates that the dental technicians are at risk to have high concentration of heavy metals in their body that is above the standard reference used for the hair.

Thus, the results of the study support its hypotheses, therefore, a special caution should be taken to protect the personnel of this profession from the toxic effect of these metals that may harm their body. Future research may investigate any clinical signs or symptoms that could be related to the high level of these metals and their effect in the body of the dental technicians.

Conclusions

Based in this study the following could be concluded:

i. The level of heavy metals found in hair of dental technicians was significantly higher than in the hair of medical technicians for under tested elements (Co, Cr and Ni).

ii. The level of Co and Ni in fingernails was significantly higher in dental technicians than in medical technicians, whereas the Cr level was very similar in both groups.

iii. Overall the levels of the heavy metals in the fingernails were relatively higher than those in hair samples.

iv. Ni was the dominant element found with the high level of concentration compared to other element. While the Co was the least.

v. Chromium was significantly found in fingernails of the medical technicians but was not found at all in their hair.

vi. Heavy metal levels was found to be affected by the age of the participants, place of work, working time, use of suction, and smoking of sheesha.

vii. Significant correlation was found between of the three metals investigated (Co, Cr and Ni) in hair as well as in fingernails. While significant correlation was found between fingernails and hair only for the Co but not for the Ni neither Cr.

viii. More that 65.5% of the dental technicians investigated had level of heavy metals in their hair sample above the standard reference.

Acknowledgment

Authors thank the Deanship of Research at Jordan University of Science and Technology for financial support of this project (188/2008). Thanks to all the dental and medical laboratory technicians who volunteered to participate in the study, and to all the staff in the Industrial Chemistry Centre in Royal Scientific Society in Jordan.

References

1. Jacobsen N, Derand T, Hensten-Pettersen A (1996) Profile of work-related health complaints among Swedish dental laboratory technicians. Community Dent Oral Epidemiol 24: 138-144.
2. Wiltshire WA, Ferreira MR, Ligthelm AJ (1996) Allergies to dental materials. Quintessence Int 27: 513-520.
3. Burgaz S, Demircigil GC, Yilmazer M, Ertas N, Kemaloglu Y, et al. (2002) Assessment of cytogenetic damage in lymphocytes and in exfoliated nasal cells of dental laboratory technicians exposed to chromium, cobalt, and nickel. Mutat Res 26: 47-56.
4. Nelson DR, Palik JF, Morris HF, Comella MC (1986) Recasting a nickel-chromium alloy. J Prosthet Dent 55: 122-127.
5. Shillingburg HT, Hobo S, Whitsett LD, Brackett SE (1997) Fundamentals of fixed prosthodontics. (3rdedn), Quintessence P, Chicago.
6. Al-Hiyasat AS, Darmani H (2005) The effects of recasting on the cytotoxicity of base metal alloys. J Prosthet Dent 93: 158-163.
7. Rom WN, Lockey JE, Lee JS, Kimball AC, Bang KM, et al. (1984) Pneumoconiosis and exposures of dental laboratory technicians. Am J Public Health 74: 1252-1257.
8. Cobe JF (1989) Materiali dentari, Masson Editrice.
9. Nordberg GF, Fowler BA, Nordberg M, Friberg L (2007) Handbook on the Toxicology of Metals. (3rd edn), Elsevier.
10. Seilkop SK, Oller AR (2003) Respiratory cancer risks associated with low-level nickel exposure: an integrated assessment based on animal, epidemiological, and mechanistic data. Regul Toxicol Pharmacol 37: 173-190.
11. Gillette B (2008) Nickel named «Allergen of the Year». ACDS adds to list of substances more attention. Dermat Times 4: 15-16.
12. ATSDR (Agency for Toxic Substances and Disease Registry) (2008) Draft Toxicological Profile for Chromium. U.S: Department of Health and Human Services, Public Health Service, ATSDR, Atlanta, GA 30333.
13. Lauwerys R, Lison D (1994) Health risks associated with cobalt exposure--an overview. Sci Total Environ 150: 1-6.
14. Nowak B, KozÅ‚owski H (1998) Heavy metals in human hair and teeth: the correlation with metal concentration in the environment. Biol Trace Elem Res 62: 213-228.
15. Kuangfei L, Yaling X, Xuefeng L, Wu Zuoli, Sandra GF Bukkens, et al. (1999) Metallic elements in hair as a biomarker of human exposure to environmental pollution: a preliminary investigation in Hubei Province. Crit Rev Plant Sci 18: 417-428.
16. Rodushkin I, Axelsson MD (2000) Application of double focusing sector field ICP-MS for multielemental characterization of human hair and nails. Part II. A study of the inhabitants of northern Sweden. Sci Total Environ 262: 21-36.
17. Massadeh AM, El-Rjoob A, Smadi H (2011) Lead, cadmium, copper, zinc, iron, and calcium in human hair as a function of gender, age, smoking, and hair dyeing. Toxicological & Environmental Chemistry 93: 494–503.
18. Abdulrahman FI, Akan JC, Chellube ZM, Waziri M (2012) Levels of Heavy Metals in Human Hair and Nail Samples from Maiduguri Metropolis, Borno State, Nigeria. World Environment 2: 81-89.
19. Bukhari IH, Rasul N, Kausar S, Naqvi SAR, Ali Z (2013) Comparative Studies

of Ni, Cd, Mn, Co, Pb, Cr and Zn in Hair, Nail and Plasma of Smokers and Non-smokers Subjects of Sargodha Zone. IJCBS 4: 28-37.

20. Nowak B, Chmielnicka J (2000) Relationship of lead and cadmium to essential elements in hair, teeth, and nails of environmentally exposed people. Ecotoxicol Environ Saf 46: 265-274.
21. Bader M, Dietz MC, Ihrig A, Triebig G (1999) Biomonitoring of manganese in blood, urine and axillary hair following low-dose exposure during the manufacture of dry cell batteries. Int Arch Occup Environ Health 72: 521-527.
22. Massadeh AM, Gharaibeh AA, Omari KW (2009) A single-step extraction method for the determination of nicotine and cotinine in Jordanian smokers' blood and urine samples by RP-HPLC and GC-MS. J Chromatogr Sci 47: 170-177.
23. Massadeh AM, Gharibeh A, Omari KW, Al-Momani I, Alomary A, et al. (2010) Simultaneous determination of Cd, Pb, Cu, Zn, and Se in human blood of jordanian smokers by ICP-OES. Biol Trace Elem Res 133: 1-11.
24. Daniel CR , Piraccini BM, Tosti A (2004) The nail and hair in forensic science. J Am Acad Dermatol 50: 258-261.
25. Barbosa F Jr, Tanus-Santos JE, Gerlach RF, Parsons PJ (2005) A critical review of biomarkers used for monitoring human exposure to lead: advantages, limitations, and future needs. Environ Health Perspect 113: 1669-1674.
26. Afridi HI, Kazi TG, Jamali MK, Kazi GH, Arain MB, et al. (2006) Evaluation of toxic metals in biological samples (scalp hair, blood and urine) of steel mill workers by electrothermal atomic absorption spectrometry. Toxicol Ind Health 22: 381-393.
27. Sukumar A, Subramanian R (2007) Relative element levels in the paired samples of scalp hair and fingernails of patients from New Delhi. Sci Total Environ 372: 474-479.
28. Bashabsheh OM (2001) Cytotoxicity of dental casting alloys used in dental laboratories in Jordan. MSc Thesis. Jordan University of Science and Technology.
29. Al-Hiyasat AS, Darmani H, Bashabsheh OM (2003) Cytotoxicity of dental casting alloys after conditioning in distilled water. Int J Prosthodont 16: 597-601.
30. Wolfsperger M, Hauser G, Gössler W, Schlagenhaufen C (1994) Heavy metals in human hair samples from Austria and Italy: influence of sex and smoking habits. Sci Total Environ 156: 235-242.
31. Vahter M, Berglund M, Akesson A, Lidén C (2002) Metals and women's health. Environ Res 88: 145-155.
32. Gammelgaard B, Veien NK (1990) Nickel in nails, hair and plasma from nickel-hypersensitive women. Acta Derm Venereol 70: 417-420.
33. Gennart JP, Baleux C, Verellen-Dumoulin C, Buchet JP, De Meyer R, et al. (1993) Increased sister chromatid exchanges and tumor markers in workers exposed to elemental chromium-, cobalt- and nickel-containing dusts. Mutat Res 299: 55-61.
34. Shirakawa T, Morimoto K (1997) Interplay of Cigarette Smoking and Occupational Exposure on Specific Immunoglobulin E Antibodies to Cobalt. Arch Environ Health 52: 124-128.
35. Vance DE, Ehmann WD, Markesbery WR (1988) Trace element content in fingernails and hair of a nonindustrialized US control population. Biol Trace Elem Res 17: 109-121.
36. Erten J, Arcasoy A, Cavdar AO, Cin S (1978) Hair zinc levels in healthy and malnourished children. Am J Clin Nutr 31: 1172-1174.

Citation: Al-Awadeen MA, Al-Hiyasat AS, Massadeh AM, Khader YS (2014) Determination of Selected Heavy Metal Levels in Scalp Hair and Fingernail Samples from Dental Laboratory Technicians. J Interdiscipl Med Dent Sci 2: 138. doi: 10.4172/2376-032X.1000138