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Original article

CONTACT SENSITIZATION TO METALS AMONG DENTAL TECHNICIAN STUDENTS IN BULGARIA IN RELATION TO THE DURATION OF THEIR EDUCATIONAL EXPOSURE

Maya Lyapina[1], Todor Kundurjiev[2], Karolina Lyubomirova[2]
1) Medical College "I. Filaretova", Medical University – Sofia, Bulgaria
2) Department of Occupational Medicine, Faculty of Public Health, Medical University - Sofia, Bulgaria.

ABSTRACT

Purpose: Sensitization to metals is a significant problem in dental, occupational exposures. The purpose of this study was to evaluate the prevalence of contact sensitization to selected metals during the course of study among students from dental technician school and the prevalence of co-sensitization.

Material and Methods: Skin patch testing with potassium dichromate, cobalt, gold, nickel, copper, palladium, aluminium, tin and sodium tetrachloropalladate (II)hydrate was performed among 150 dental technician students (38 – 1st year of study,40 – 2nd year of study and 38 – 3rd year of study); the control group included 34 students without educational exposure to metals. Chi-square test, Fisher Exact Test and multiple binary logistic regression were used in data analysis.

Results: During the educational course of dental technician students, a clear tendency of increase in the prevalence of sensitization to nickel (1st year of study - 10.5%, 3rd year of study - 36.8% cobalt (13.2% vs 39.5%) and palladium(II)chloride (10.5% vs 26.3%) was established. For the whole studied population, the prevalence of positive reactions to sodium tetrachloropalladate (II) hydrate was the highest – 30%; the highest recorded value was among the 2nd year students – 57.5%. The prevalence of sensitization to more than one metal allergen among the studied population was high (66.7%), the highest value was reported among 3rd-year dental technician students (78.9%).

Conclusions: Our data indicate a high risk of contact sensitization to metals relevant for the dental technician students, which increases in the course of educational exposure for some of the metal haptens. Sodium tetrachloropalladate(II) hydrate could be outlined as a sensitizer of prominent importance, probably due to the increased sensitivity of this test salt. Additional and studies, including more respondents from the othe Colleges in Bulgaria are recommended. Adequate prevention programs and information should be provided, and the European Union regulations should be properly applied.

Keywords: metals, occupational exposure, contact sensitization, dental technician students, educational exposure, apprenticeship,

INTRODUCTION

Metal allergens are important contact sensitizers. Although consumer exposures (jewelry, clothing clasps, mobile phones, leather goods, etc.) account for most cases of metal allergy, possible occupational exposures should always be kept in mind in case of positive skin patch test results.

Sensitization to metals is an important problem for dental professionals subject to occupational exposure. The prevalence of occupational skin diseases (allergic contact dermatoses with contact urticaria included, and irritant dermatoses) among dental personnel was estimated to be 30% - 50% [1] and the prevalence of allergies to metals among dental professionals with hand dermatitis is also high [2]. Among the most harmful activities being a source of the occupational exposure to metals of dental technicians and apprentices are metal casting, metal grinding and polishing, electro-spot welding, sandblasting of metal surfaces of crowns, bridges and prosthesis and wire bending.

Moreover, contact sensitization to one metal relevant for a dental practice is often accompanied by co-sensitization to other metals. Nickel was considered the most common sensitizer [3]. Contact sensitization to nickel is often accompanied by contact sensitization to chromium and cobalt. During patch testing of 1208 patients with contact dermatitis, positive reactions to two or three of the metals were found among 18.5% of investigated subjects [4].

We didn't find data in the available literature concerning the prevalence of co-sensitization to metal ions relevant for dentistry among students from dental technician school.

The aim of this study was to evaluate the prevalence of contact sensitization to selected metals during the course of study among students from dental technician school and the prevalence of co-sensitization.

MATERIAL AND METHODS

Experimental design

A cross-sectional study was conducted in June 2018 – February 2019 in accordance with the Helsinki Declaration upon obtaining approval from the Medical Ethics Board at Medical University – Sofia. A total of 150 par-

ticipants (54 men and 96 women), divided into 4 groups, were included in the study: dental technician students from the Medical College – Sofia – 1st, 2nd, and 3rd year of study, as well as students from other majors (public health inspectors and rehabilitators), not exposed to metals during their course of study, served as a control group. The demographic characteristics of the groups are presented in table 1. All the participants were informed about the purpose of the study and gave their written informed consent before its commencement.

Table 1. Demographic characteristics of the studied population.

Group	Gender		Total [n / (%)]	Age		
	female [n / (%)]	male [n / (%)]		female [Mean±SD]	male [Mean±SD]	Total [Mean±SD]
Dental technician students – 1st year	22 (22.9)	16 (29.6)	38 (25.3)	20.36±2.68	21.38±5.08	20.79±3.85
Dental technician students – 2nd year	29 (30.2)	11 (20.4)	40 (26.7)	22.76±4.23	28.00±9.43	24.20±6.43
Dental technician students – 3rd year	24 (25.0)	14 (25.9)	38 (25.3)	27.13±8.72	26.43±4.79	26.87±7.45
Students without exposure to metals	21 (21.9)	13 (24.1)	34 (22.7)	28.14±12.85	24.23±8.52	26.65±11.41
Total	96 (100.0)	54 (100.0)	150 (100.0)	24.48±8.34	24.72±7,25	24.57±7.94

Skin patch testing

All the participants were skin patch tested with potassium dichromate (0.5% pet), cobalt(II)chloride hexahydrate (1.0% pet), gold(I)sodium thiosulfate dehydrate (2.0% pet), nickel(II)sulfate hexahydrate (5.0% pet), copper(II)sulfate pentahydrate (2.0% pet), palladium(II)chloride (2.0% pet), aluminium(III)chloride hexahydrate (2.0% pet), tin (50.0% pet) and sodium tetrachloropalladate(II) hydrate (3.0% pet) – Chemotechnique Diagnostics, according to the Jadassohn & Bloch classical methods for diagnosis of contact allergy, by placing the allergens in IQ-Ultra hypoallergenic patches of Chemotechnique Diagnostics (IQ Chambers®, Vellinge, Sweden). A mandatory requirement one week before and during the testing was a lack of anti-allergic medication. Patches with allergens were applied on the back of the tested individuals; reading of the test was performed after 48 hours, several hours after removing the patches, with follow-up after 72 hours.

The reaction sites were interpreted on the basis of the interpretation key recommended by the International Contact Dermatitis Research Group (ICDRG).

Statistical methods

The statistical data were calculated with SPSS 19.0. The following statistics available for cross-tabulation were used: $\chi 2$ test, Fisher Exact Test for statistical significance, multiple binary logistic regression analysis. Values of $p<0.05$ were accepted as statistically significant.

RESULTS

Women predominated of in all the investigated groups without statistical significance ($\chi 2=3.8$, $p=0.187$). The percentage of individuals without a history of allergic pathology and skin complaints was higher, but no significant differences were observed.

Data on the prevalence of sensitization to the selected metals in the defined groups are summarized in table 2.

Table 2. Prevalence of sensitization to the selected metals in the defined groups.

Positive reactions to:	Students without exposure to metals	Dental technician students 1st year	Dental technician students 2nd year	Dental technician students 3rd year	Chi-square	df	p-value
	n(%)	n(%)	n(%)	n(%)			
Potassium dichromate	8 (23.5)	7 (18.4)	14 (35.0)	6 (15.8)	4,77	3	0.190
Cobalt(II)chloride hexahydrate	11 (32.4)$_{a,b}$	5 (13.2)$_{b}$	8 (20.0)$_{a,b}$	15 (39.5)$_{a}$	8,3	3	0.040
Gold(I)sodium thiosulfate dehydrate	13 (38.2)$_{a}$	6 (15.8)$_{b}$	19 (47.5)$_{a}$	19 (50.0)$_{a}$	11,81	3	0.008

Nickel(II)sulfate hexahydrate	11 (32.4)	4 (10.5)	10 (25.0)	14 (36.8)	7,79	3	0.051
Copper(II)sulfate pentahydrate	14 (41.2)	7 (18.4)	14 (18.4)	9 (23.7)	5,69	3	0.128
Palladium(II)chloride	8 (23.5)	4 (10.5)	15 (23.7)	10 (26.3)	7,71	3	0.052
Aluminium(III)chloride hexahydrate	4 (11.8)	3 (7.9)	1 (2.5)	3 (7.9)			0.463*
Tin	3 (8.8)	1 (2.6)	0 (0.0)	1 (2.6)			0.463*
Sodium tetrachloropalladate(II) hydrate	3 (8.8)$_a$	8 (21.1)$_{a,b}$	23 (57.5)$_c$	11 (28.9)$_b$	23,13	3	<0.001

Note: *Fisher's Exact Test; Different letters show a statistically significant difference between the proportions (%) in the groups ($p<0.05$), and the identical letters indicate that there is no significant difference.

The statistical analysis revealed a significantly higher prevalence of sensitization to cobalt (Co) in the group of 3rd-year dental technician students versus 1st year and 2nd-year students. Interestingly, the prevalence of sensitization among the students from the control group was also significantly higher compared to 1st and 2nd-year dental technician students ($\chi2=8.304$, $p=0.040$).

The prevalence of contact sensitization to gold (Au) among 1st-year dental technician students was significantly lower compared to 2nd year and 3rd-year dental technician students, as well as to the control group ($\chi2=1.812$, $p=0.035$, [OR=0.290 (95% CI 0.092- 0.916]).

Analyzing the prevalence of sensitization to nickel (Ni), a tendency for its increase during the course of study was observed, though no significance was established ($\chi2=7.785$, $p=0.035$, [OR=0.235 (95% CI 4.230- 0.904]).

Further, analyzing the prevalence of contact sensitization to sodium tetrachloropalladate(II)hydrate, it was found to be the highest among the 2nd year dental technician students (57.5%), being significantly higher compared to 1st year and 3rd year dental technician students, as well as to the control group ($\chi2=23.134$, $p<0.001$, [OR=18.476 (95% CI 4.230- 80.711]). The prevalence of sensitization among the 3rd year dental technician students was significantly higher compared to the control group ($p=0.039$, [OR=4.621 (95% CI 1.081- 19.746]).

Data on the prevalence of sensitization to the selected metals by gender are summarized in table 3.

Table 3. Prevalence of positive skin patch tests to the selected metals according to gender.

Positive reactions to:	Men	Women	Total	Chi-square	df	p-value
	n(%)	n(%)	n(%)			
Potassium dichromate	7 (13.0)	28 (29.2)	35 (23.3)	5,07	1	0.024
Cobalt(II)chloride hexahydrate	13 (24.1)	26 (27.1)	39 (26.0)	0,16	1	0.687
Gold(I)sodium thiosulfate dehydrate	17 (31.5)	40 (41.7)	57 (26.0)	1,52	1	0.217
Nickel(II)sulfate hexahydrate	7 (13.0)	32 (33.3)	39 (26.0)	7,45	1	0.006
Copper(II)sulfate pentahydrate	13 (24.1)	31 (32.3)	44 (29.3)	1,13	1	0.289
Palladium(II)chloride	15 (27.8)	22 (22.9)	37 (24.7)	0,44	1	0.507
Aluminium(III)chloride hexahydrate	2 (3.7)	9 (9.4)	11 (7.3)			0.329*
Tin	3 (5.6)	2 (2.1)	5 (3.3)			0.351*
Sodium tetrachloro-palladate(II) hydrate	15 (27.8)	30 (31.3)	45 (30.0)	0,2	1	0.656

Note: *Fisher's Exact Test

The statistical analysis revealed a significantly increased prevalence of contact sensitization among women to potassium dichromate ($p=0.048$, [OR = 2.611 (95% CI 1.007- 6.769]) and to nickel ($p=0.021$, [OR = 3.066 (95% CI 1.181- 7.960]).

The results on the distribution of sensitization prevalence to the selected metals by age (under 30 years) of the studied population are presented below – table 4.

Table 4. Prevalence of positive skin patch tests to the selected metals according to age.

Positive reactions to:	Age group		Chi-square	df	p-value
	≤30 year n(%)	>30 year n(%)			
Potassium dichromate	31 (25.0)	4 (15.0)	1,11	1	0.292
Cobalt(II)chloride hexahydrate	29 (23.4)	10 (38.5)	2,54	1	0.111
Gold(I)sodium thiosulfate dehydrate	48 (38.7)	9 (34.6)	0,15	1	0.696
Nickel(II)sulfate hexahydrate	31 (25.0)	8 (30.8)	0,37	1	0.542
Copper(II)sulfate pentahydrate	33 (26.6)	11 (42.3)	2,55	1	0.110
Palladium(II)chloride	23 (18.5)	14 (53.8)	14,41	1	0.000
Aluminium(III)chloride hexahydrate	8 (6.5)	3 (11.5)			0.405*
Tin	5 (4.0)	0 (0.0)			0.588*
Sodium tetrachloropalladate(II) hydrate	35 (28.2)	10 (38.5)	0,64	1	0.424

Note: *Fisher's Exact Test

The only significant difference revealed during the statistical analysis was the higher prevalence of contact sensitization to palladium (Pd) in the group of individuals over 30 years ($\chi 2=14.411$, $P<0.001$).

The multiple binary logistic regression analysis didn't establish association between the other independent factors (age, history of allergic pathology and skin complaints, past exposures e.g. occupational, to chemical agents and metals, reported by the respondents), with contact sensitization to meatals.

Finally, we evaluated the prevalence of co-sensitization to the selected metal ions among the studied population. The results are presented in table 5.

Table 5. Prevalence of cross/concomitant sensitization to the selected metals in the defined groups.

Target group		Negative reactions	Positive reactions to:	
			One allergen	Two and more allergens
		n (%)	n (%)	n (%)
Students without exposure to metals	female	3 (14.3)	4 (19)	14 (66.7)
	male	1 (7.7)	2 (15.4)	10 (76.9)
	total	4 (11.8)	6 (17.6)	24 (70.6)
Dental technician students 1st year	female	8 (36.4)	5 (22.7)	9 (40.9)
	male	6 (37.5)	3 (18.8)	7 (43.8)
	total	14 (36.8)	8 (21.1)	16 (42.1)
Dental technician students 2nd year	female	3 (10.3)	6 (20.7)	20 (69)
	male	0 (0)	1 (9.1)	10 (90.9)
	total	3 (7.5)	7 (17.5)	30 (75.0)
Dental technician students 3rd year	female	1 (4.2)	4 (16.7)	19 (79.2)
	male	0 (0)	3 (21.4)	11 (78.6)
	total	1 (2.6)	7 (18.4)	30 (78.9)
Total	female	14 (14.6)	18 (18.8)	64 (66.7)
	male	8 (14.8)	10 (18.5)	36 (66.7)
	total	22 (14.7)	28 (18.7)	100 (66.7)

The prevalence of individuals with positive reactions to more than one metal in all the defined groups was significantly higher ($\chi 2=23.048$, $P=0.001$).

DISCUSSION

Numerous chemical substances, many of which allergens, being ingredients of various dental materials, impose serious health risk for dental technicians. Their occupational exposure starts as early as during the course of their practical education.

The prevalence of contact sensitization to metals in the overall population is found to be high. It is evaluated that up to 17% of women and 3% of men are sensitized to nickel and 1-3% - to cobalt and chromium. Well known is the significance of nickel and cobalt important as contact allergens [5]. Contact allergy to gold and palladium requires particular attention since its prevalence is also high. Palladium allergy is believed to be primarily a result of cross-sensitization with nickel, and gold allergy is rarely of clinical significance given its widespread prevalence. The epidemiology of metal allergy in Europe is changing – for example, in Denmark, the prevalence of sensitization to nickel decreased after the regulatory intervention on the amount of nickel in consumer products. In the United States, the prevalence of nickel allergy is growing, probably because of the absence of regulation [6].

Dental alloys mainly accounting for contact allergy are nickel sulphate, chromium, mercury, palladium, and gold.

Nickel, palladium and cobalt were identified as the most important occupational sensitizers in dental practice [7]. Its use in everyday life is still wide as well.

In our study, we observed a clear tendency for an increase in the prevalence of sensitization to nickel during the educational course of dental technician students – from 10.5% in 1st year of study to 36.8% in the 3rd year, very similar but higher compared to the control group (32.4%), but without significance. Instead of the fact that the sensitization prevalence is higher among the group of students over the age of 30, we could suggest that longer exposure to nickel containing dental materials during the educational course of dental technician students could contribute to the rate of sensitization to nickel. Moreover, women could be outlined as a particularly vulnerable group for the onset of contact sensitization to nickel.

Cobalt is a well-known skin sensitizer, and allergy to cobalt is common, with 6.2-8.8% of dermatitis patients being affected [8] and occurs in about 1% of the total population [9]. In 2016, cobalt was named "Allergen of the Year" by the American Contact Dermatitis Society [10]. The release of cobalt, nickel, and chromium from some cobalt-containing hard metal alloys was studied. Thyssen et al. (2012) studied the cobalt ion release from cobalt-containing dental alloys as well as from mobile phones using cobalt spot test. It was established that six of eight dental alloys released cobalt in the cobalt spot test. Isolated patch test reactivity to cobalt was less associated with occupational dermatitis and hand eczema than patch test reactivity to cobalt in combination with other contact allergies [11]. Cobalt, chromium, and nickel skin and respiratory exposure in 13 dental technicians working with tools and alloys was quantified. It was concluded that cobalt skin doses might potentially elicit allergic contact dermatitis [12].

The results from our study concerning the prevalence of sensitization to cobalt among dental technician students are similar to those regarding the one to nickel – a triple increase during the course of education was established. Again, we could suppose a possible role of exposure during the educational course for the contact sensitization development. The group of women again was at higher risk of sensitization onset. Finally, our results confirm previous observations that contact sensitization to cobalt very often accompanies the one to nickel.

The sensitization to palladium in dental practice is a topic of research interest. Consumers are exposed to palladium mainly from jewelry and dental restorations. In medicine, palladium is mainly used as a component of denture alloys. Palladium alloy is believed to be safe despite the concerns about the effects of low levels of corrosion products. Since palladium and nickel tend to cross-react, the sensitization to palladium very often accompanies the sensitization to nickel [13].

Our results on sensitization prevalence to palladium are similar to the one discussed above. In the 3rd year of study, it was 2.5 times higher if compared to the one in the 1st year, being some higher if compared to the one in the control group. Since the statistical analysis revealed that the prevalence of sensitization was significantly higher in the group of individuals over 30 years, we could suggest that the longer duration of exposure (both occupational and consumer) contributes to sensitization onset. Interestingly, in the case of palladium sensitization prevalence, men were outlined as a more vulnerable group.

Literature data [14] indicate that the sensitivity of patch testing with sodium tetrachloropalladate(II)hydrate 3% pet is increased compared to palladium chloride 2% pet, and $Na_{(2)}[PdCl_{(4)}]$ is a better test salt for diagnosing palladium allergy. That's why in the present study, we decided to perform patch testing with both palladium salts and to compare the prevalence of positive patch tests.

Our results confirm the statements cited above – the prevalence of positive patch test reactions to sodium tetrachloropalladate(II)hydrate was the highest one – 30%. For 2nd year students, it was the highest recorded as well – 57.5% (versus 8.8% for the control group). We can outline as a sensitizer of prominent importance for dental technician students sodium tetrachloropalladate(II)hydrate, probably due to the increased sensitivity of the test salt.

Jewelry and dental gold alloys are generally accepted as non-sensitizing materials. Gold is widely used in dentistry (for the restoration of rear dental arches) as well as in piercing. The gold alloys are composed of 80 % of this metal [15]. In several studies, it resulted in the most common allergen after the nickel. According to the results obtained by Stoeva, the sensitization rate to nickel was highest (22.8%), followed by the ones to gold (17.0%), cobalt (10.9%), copper (9.4%) and palladium (7.0%). According to the author, highest was the sensitization rate to gold in the corresponding age group of students (25,9%), and 13.7% - among dental technicians [16].

The sensitization prevalence to gold salts among 1st-year dental technician students was significantly lower

if compared to the 2nd and 3rd-year students, as well as to the control group. It was somewhat lower among the individuals under 30 years, but, nevertheless, we can't give a categorical statement about the role of educational exposure to gold for the sensitization onset. Once again, women were outlined as a more vulnerable group.

The world production of copper is steadily increasing. Although humans are widely exposed to copper-containing items on the skin and mucosa, allergic reactions are infrequently reported [17]. In a few and selected cases, copper can result in clinically relevant allergic reactions – immunologic contact urticaria, allergic contact dermatitis, systemic allergic reactions and contact stomatitis.

Our findings confirm the main role of continuous consumer exposure to copper-containing product for sensitization development. It was highest in the control group and higher among individuals over 30 years old. Once again, women were found to be at increased risk. Moreover, the prevalence of positive patch tests calculated for the whole studied population was 29.3%, somewhat lower than the highest one – to sodium tetrachloropalladate(II) hydrate.

Chromium is considered to be the fourth substance most commonly established in the earth's crust. Trivalent chromium compounds are used for leather tanning, and chromium may from leather goods. [18]. Induction of sensitization only occurs after exposure to hexavalent chromium. The co-occurrence of allergy to cobalt, chromium, and nickel was analyzed. Allergy to any metal was shown in 31% of patients, allergy to cobalt in 14%, allergy to chromium in 7%, and allergy to nickel in 20% [19].

Our findings don't confirm a possible role of the duration of exposure during the practical education of dental technician students. An increase of positive skin patch test reactions was established only during the second year of study, without statistical significance. Women were at significantly increased risk of contact sensitization manifestation.

The prevalence of positive skin patch test reactions to aluminium and tin was quite low for both dental technician students and the control group – as illustrated in table 3. Higher is the risk of sensitization to aluminium among women and tin – among men.

The observed by us high prevalence of contact sensitization to metals among the tested group could be partially explained by the lack of delayed reading at day 7. We would recommend such reading to be performed as a rule in the cases of patch testing for metals sensitization.

Often, contact sensitization to one metal relevant for a dental practice is accompanied by concomitant/cross sensitization to other metals. Accordingly, concomitant reactivity to cobalt and nickel in patch testing is often observed [20].

In the present study, we established a high prevalence of sensitization to more than one metal allergen among the population studied by us, being highest in the group of 3rd-year dental technician students. It is difficult to explain these results basing only on the sample tested by us. We could assume that, probably, this is due to the longer duration of exposure during the course of education of dental technician students, and/or to the discussed above greater chance for concomitant occupational and consumer exposures to metals related to the increasing use of metal accessories such as piercings, for example.

CONCLUSIONS:

Our data indicate a high risk of contact sensitization to metals among dental technician students, increasing with the duration of educational exposure for some of the metal haptens. We could also assume the role of multiple consumer exposures to metals. The population of dental technician students tested by us showed very high levels of metal sensitization compared to the general population in Europe. Sodium tetrachloropalladate(II)hydrate could be outlined as a sensitizer of prominent importance, probably due to the increased sensitivity of this test salt. Additional and studies, including more respondents from the othe Colleges in Bulgaria are recommended. Adequate prevention programs and information should be provided, and the European Union regulations should be properly applied.

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Address for correspondence:
Assoc. Prof. Maya Lyapina, MD, PhD
Medical College "I. Filaretova", Medical University - Sofia,
3, "I. Filaretova" str., 1606 Sofia, Bulgaria
E-mail: saly_grigory@abv.bg,