THE EFFECTS OF AMALGAM RESTORATIONS ON SALIVARY MERCURY CONCENTRATIONS AND TOTAL ANTIOXIDANT ACTIVITY

AMALGAM RESTORASYONLARININ TÜKÜRÜK CİVA KONSANTRASYONU VE TOTAL ANTİOKSİDAN SEVİYESİ ÜZERİNE ETKİSİNİN İNCELENMESİ

Dr. Dt. H. Nur KOCAKERİM İSKENDER,[1] Dr. Dt. Serpil KARAOĞLANOĞLU,[2] Dr. Dt. Nilgün AKGÜL,[3] Fevzi POLAT, MD;[4] Dr. Dt. Nilgün SEVEN,[3]
[1]Çankaya Dental Clinic, Ankara,Turkey
[2]75. Year Oral and Teeth Hospital Ankara, Turkey
[3]Department of Restoratif Dentistry, School of Dentistry, Atatürk University, Erzurum, Turkey.
[4]Department of Biochemistry, Faculty of Medicine, Atatürk University, Erzurum, Turkey.
Geliş tarihi: 28/06/2017 Kabul tarihi: 19/07/2017

Yazarlar herhangi bir finansal destek kullanmamış olup yazarlar arasında çıkar çatışması yoktur.

ABSTRACT

The aim of the present study was to examine the relationship between mercury (Hg) levels and Total Antioksidant Activity (TAA) in saliva of subjects having amalgam restorations and having not such fillings.
A total of 48 subjects participated in this study , 35 whom hadamalgam restorations and the 13 had no dental amalgams. In the amalgam group silicon impressions were taken and the total surface and occlusal surface areas of filings were calculated. Unsitimulated saliva samples of all subjects were collected and the levels of Hg and TAA were determined.
The mean Hg concentrations of saliva determined as 21.41±26.07µg/l in subjects with amalgam restorations, and were 5.88±2.57µg /l in subjects without amalgams. Saliva Hg concentrations were found to be positively correlated with the number of amalgam fillings and were statistically lower in the group without dental amalgams . ($p<0.001$). the mean total and occlusal surface areas of the amalgam fillings were determined as 193.83±85.74 mm2 and 153.90±64.87 mm2 , respectively. Statically although there were no correlation between the total surface area of the restorations and salivary Hg levels ($p>0.05$), a positive relationship were found between the occlusal surface area of the amalgam fillings and Hg levels of saliva ($p<0.05$).
The mean TAA levels were 0.61±0.39 mmol/l for amalgam group and 0,49±0.13 mmol/l for the nonamalgam group . It was found that neither the number of amalgam fillings nor the total surface and occlusal surface area of the restorations did not correlated with the salivary TAA concentrations ($p>0.05$).
The results of the study showed that although amalgam fillings were one the sources of Hg in saliva and the occlusal surface area of these restorations were an effective factor on the salivary Hg levels, These influences were not important on the TAA statusof the saliva.

Keywords: *saliva, mercury, total antioxidant activity*

Yazışma adresi/Correspondence Address: Dr. Dt. Serpil KARAOĞLANOĞLU, 75. Year Oral and Teeth Hospital Ankara, Turkey
Tel: 0312 3041118 / 1443 **e-mail:** skaraoglanoglu2@yahoo.com

ÖZ

Bu çalışmanın amacı amalgam dolgusu bulunan ve bulunmayan bireyleri tükürük civa(Hg) seviyeleri ve total antioksidan aktiviteleri (TAA) arasındaki ilişkiyi incelemektir.

Çalışmaya 35 amalgam dolgulu , 13 amalgam dolgusu toplam 48 birey katıldı.Amalgam dolgulu bireylerin ağızlarından ölçü alındı ve restorasyonların yüzey alanları hesaplandı.Tüm bireylerde uyarılmamış tükürük örnekleri toplanarak , tükürük Hg ve TAA düzeyleri belirlendi.

Ortalama tükürük Hg düzeyleri amalgam dolgulu bireylerde 21.41±26.07µg/l ,amalgam dolgusu bulunmayan bireylerde 5.88±2.57µg /l olarak tespit edildi.Tükürük Hg konsantrasyonlarınınamalgam dolgularının sayısıyla pozitif korelasyon gösterdiği ve dental amalgam olmayan bireylerde istatistiksel olarak daha düşük olduğu belirlendi. (p<0.001)

Amalgam dolguların toplam yüzey alanları veokluzal yüzey alanları ortalamaları ise sırayla 193.83±85.74 mm2 ve 153.90±64.87 mm2 olarak tespit edildi.İstatistiksel olarak restorasyonların toplam alanları ile tükürük Hg seviyesi arasında bir korelasyon bulunmamasına karşın (p>0.05), restorasyonların yüzey alanları ile tükürük Hg seviyesi arasında pozitif bir ilişki bulundu (p<0.05).

Ortalama TAA seviyeleri ise amalgam dolgulu bireylerde 0.61±0.39 mmol/l, amalgam dolgusuz grupta ise 0,49±0.13 mmol/l idi. Gerek amalgam dolgu sayısının ve gerekse amalgam restorasyonlarının toplam ve okluzal alanlarının tükürük TAA konsantrasyonları ile bir korelasyon göstrmediği saptandı(p>0.05).

Bu çalışmanın sonuçları amalgam dolguların tükürükteki Hg'nin başlıca kaynaklarından biri olduğunu ve bu restorasyonların okluzal yüzey alanlarının tükürük Hg düzeyi üzerinde etkili bir unsur olmasına karşın. Bu etkinin tükürüğün TAA durumu üzerinde önemli olmadığını gösterdi.

Anahtar Kelimeler: *Tükürük, civa , total antioksidan aktivitesi*

INTRODUCTION

The possible toxic effects of the mercury content in amalgam has been a subject of discussion ever since the material's initial use in the field of dentistry. It is known that individuals with amalgam fillings may suffer from the toxic effects of mercury vapors released from amalgams and from elemental and ionic mercury, (1) which may lead to increased levels of mercury in various tissue and bodily fluids such as blood, plasma and saliva (2-10).

Research has shown that, as with other toxic metals, the accumulation of mercury in the body can lead to oxidative stress and the production of Reactive Oxygen Species (ROS), which, in addition to aging and disease mechanisms, is believed to play an important role in mercury toxicity (11). In addition to causing peroxidative injury to membrane lipids and proteins, ROS may induce DNA fragmentation that can lead to disruption of nerve cell function and integrity (12).

In recent years, studies have been conducted to examine the effects of mercury on overall Total Antioxidant Activity (TAA) and specific antioxidant enzymes such as SOD, GPx and CAT in various bodily tissues (13-16) and fluids such as plasma (17-18) and saliva (19-20). However, relatively few studies have investigated the relationship between mercury released from dental amalgams and antioxidant systems (4,17,21).

This study aimed to examine the effects of mercury leached from amalgam fillings on salivary mercury (S-Hg) levels as well as the relationship between dental amalgams and salivary Total Antioxidant Activity (S-TAA).

MATERIALS AND METHODS

Participant Selection

The study was conducted among patients applying to the Atatürk University Faculty of Dentistry. All of the patients gave their written informed consent.

The study population was comprised of 48 individuals (24 males, 24 females; age range: 20-32 years). Of these, 33 (14 males, 19 females) had amalgam restorations and 15 (10 males, 5 females) had no amalgam restorations. All of the subjects were Erzurum residents who were born in the city and had spent most of their lives there. The presence of any of the following were used as exclusion criteria: systemic diseases, (22-23) use of any type of medication in the previous 3 months, (24) tobacco/alcohol consumption, (25)

occupational exposure to mercury, (7,26) new amalgam restorations inserted in the past year, consumption of any fish or alcohol during the previous month, any parafunctional habits (e.g. bruxism), frequent gum chewing (every day, several times a day) (3,27 -29).
In addition, individuals found to have periodontal disease (30) or untreated dental caries upon clinical examination were also excluded from the study (31-32).

Measurement of Restoration Surface Area in Participants with Amalgams

For individuals with amalgams, clinical examination included counting and measuring the number of amalgam fillings and amalgam surfaces using elastometric impression material. Models were constructed on which the borders of the amalgam surfaces were drawn. Occlusal surface area and total surface area of amalgams were measured at the Süleyman Demirel University Cad-Cam Research and Implementation Center using a 3D Scanning and Modeling Unit (Counting Measurement Machine-CMM) (Figure 3) comprised of a scanning unit (Renishaw Cyclone Series 2) and an interpretation unit (Renishaw SP 620). The unit conducts a point-by-point examination of the 3D coordinates of previously described areas to construct appropriate surfaces. All described surfaces are then automatically numbered and measured.

Saliva Sample Collection

Participants were instructed not to eat or drink anything for 1 hour prior to saliva sample collection. Samples were collected between 9 am-12 pm. Participants were instructed to rinse their mouth 5 times with distilled water, swallow all saliva accumulated over the next 5 minutes and then fill the test tubes provided with newly formed saliva. 12 Saliva samples of 3.5 ml were collected from each participant and were measured for mercury and TAA levels. With the exception of those used for mercury analysis, all samples were centrifuged at low speed in order to remove any waste products. All samples were stored at -80°C until analysis.

Mercury Analysis

Saliva samples were prepared for mercury analysis using a closed microwave digestion unit (Milestone ETHOS 1600). Cold vapor atomic absorption spectrometric (CVAAS) analysis is the most common method used for the measurement of mercury levels in biological samples (33). In the present study, mercury analysis of saliva samples was performed using a Perkin Elmer Simaa 6000Atomic Absorption Spectrometer with an FIAS 100 Hydride System. This system applies the same procedures as CVAAS, is capable of analyzing other elements in addition to mercury and has a sensitivity of 10 µg/L (for 0.07 abs).

Total Antioxidant Activity (TAA) Analysis

Salivary TAA levels were measured using a Cayman Chemical Antioxidant Test Kit (Catalog No. 709001, Cayman Chemical Comp, USA). Saliva samples were prepared according to the manufacturer's instructions.

Statistical Analysis

Statistical analysis of data was performed using the SPSS 10.01 software package. 169 T-test was used to analyze differences between groups, and correlation analysis was used to analyze any relationships between parameters.

RESULTS

Mean, minimum and maximum values for number of amalgam fillings, number of amalgam surfaces, total amalgam surface area and occlusal surface area in participants with amalgams are shown in Table 1.
The mean S-Hg level was higher for females than for males, whereas mean S-TAA was higher for males than for females; however, these differences were not statistically significant ($p>0.05$) (Table 2).
Mean S-Hg level for participants with amalgams was 8.56±4.62 µg/l, compared to 5.88±2.57 µg/l for those without amalgams. The difference between these levels was statistically significant ($p<0.05$) (Table 3,). Mean S-TAA for participants with amalgams was 0.61±0.39 mmol/l, compared to 0.49±0.13 mmol/l for those without amalgams. This difference was not statistically significant ($p>0.05$) (Table 3).
The statistical relationship between S-Hg levels and S-TAA and the number of amalgam fillings, number of amalgam surfaces, total amalgam surface area and amalgam occlusal surface area is given in Table 4. The relationship between both number of amalgam fillings and occlusal surface area and S-HG levels was found to be statistically significant ($p<0.05$) , whereas no statistically significant relationship was found between S-HG levels and number of amalgam surfaces or total amalgam surface area ($p>0.05$) (Table 5). Moreover, no statistically significant relationship was

found between any of the amalgam-related parameters and S-TAA (p>0.05) (Table 5).
A positive relationship was found between S-Hg levels and S-TAA (p<0.05) (Table 4).

Table 1: Mean values (x), standard deviations (SD) and minimum and maximum values for number of amalgam restorations, number of amalgam surfaces, occlusal surface area and total amalgam surface area.

	x	*SD*	*Minimum*	*Maximum*
Number of amalgams	6.7	2.17	2	11
Number of amalgam surfaces	10.76	4.49	4	24
Amalgam occlusal surface area (mm2)	153.90	64.87	48.85	357.60
Total amalgam surface area (mm2)	193.83	85.74	55.96	477.76

Table 2: Saliva mercury levels and total antioxidant activity (mean levels and standard deviations), by sex of participants.

	Male (n=24)	*Female (n=24)*		
	x±SD	x±SD	t	p
T-Hg (µg/l)	7.54±4.99	7.91±3.44	-0.301	0.765
T-TAA (mmol/l)	0.60±0.41	0.54±0.25	0.587	0.560

Table 3: Saliva mercury levels and total antioxidant activity (mean levels and standard deviations), by amalgam status (participants with amalgams vs participants without amalgams).

	With amalgams (n=33)	*Without amalgams (n=15)*		
	x±SD	x±SD	t	p
T-Hg (µg/l)	8.56±4.62	5.88±2.57	2.092	0.042*
T-TAA (mmol/l)	0.61±0.39	0.49±0.13	1.178	0.245

** p<0,05*

Tablo 4: The relationship between saliva mercury levels and saliva Total Antioxidant Activity

	N	*T-TAA (mmol/l)*
T-Hg	48	r=0.288*
(µg/l)		p= 0.047

** p<0.05,** p<0.001*

Table 5: The relationship between saliva mercury levels and saliva Total Antioxidant Activity among participants with amalgams and the number of amalgam restorations, number of amalgam surfaces, occlusal surface area and total amalgam surface.

	N	*Number of amalgams*	*Number of amalgam surfaces*	*Total amalgam surface area*	*Amalgam occlusal surface area*
T-Hg (µg/l)	33	r= 0.385*	r= 0.225	r= 0.222	r=0.423*
		p= 0.027	p=0.208	p=0.214	p=0.014
T-TAA (mmol/l)	33	r= 0.209	r= 0.254	r= 0.196	r=0.185
		p= 0.242	p=0.154	p=0.273	p=0.302

**p<0.05*

DISCUSSION

The findings of our study indicate that amalgam fillings are a significant source of mercury in saliva. S-Hg levels among participants with amalgam restorations were found to be statistically higher than S-Hg levels among participants without amalgams. This finding is in line with those of previous studies (34-36).

In our study, mean S-Hg levels of participants with amalgams and those without amalgams were 8.56±4.62 µg/l (range: 1.17-22.45 µg/l) and 5.88±2.57 µg/l (range: 0.67-10.60 µg/l), respectively. S-Hg levels of participants with amalgams in this study were similar to levels reported by Gradl and Gebhardt (37) and Monaci et al. Although the mean S-Hg level of participants without amalgams in this study was higher than levels found in some previous studies, (38-39) the range of values is consistent with those reported in the literature. The difference in values reported in this study and previous studies may be associated with various factors, such as the time of day when the saliva samples were collected (3). It has also been suggested that since salivary mercury includes mercury from squamous epithelial cells and bacteria as well as mercury vapors, differences in S-HG levels may be due to variations in the amount of epithelial cells and bacteria found in individual saliva samples (40).

Numerous studies have shown that saliva mercury levels are higher among individuals with amalgam restorations in comparison to those without amalgam restorations, regardless of whether saliva collection was stimulated or unstimulated (41-42). Our study also found that the concentration of mercury in the saliva of individuals with amalgam restorations was significantly higher when compared to individuals without amalgams (p<0.05).

Our study found the number of fillings and the amalgam occlusal surface area had a significant effect on the S-Hg levels of individuals with amalgam fillings ($p<0.05$). This is in line with studies by Monaci et al, (43)Pizzichini et al (19-20) and Ganss et al, (3) all of which found a relationship between number of amalgam fillings and saliva mercury levels; however, it is in conflict with a study by Mumcu, (39) which found no significant correlation between the number of amalgam fillings or amalgam occlusal surface area. In the latter study, amalgams were placed in a single sitting, and S-Hg levels were measured immediately after, 24 h after and 1 month after amalgam placement. The difference in methodology between this study and our study may account for the different findings.

Our study found total number of amalgam surfaces and total amalgam surface area had no significant effect on salivary mercury levels ($p>0.05$). This finding conflicts with those of previous studies by Lygre et aı (44) and Ganss et al (3) The differences in findings may be explained by the use of stimulated saliva samples in the case of Lygre et al, (44) and in the case of Ganss et al, (3) by the lower sensitivity of the technique used for measuring amalgam surface area in comparison to the method used in our study.

Whereas S-Hg concentrations were found to be affected by number of amalgam fillings and amalgam occlusal area, no such relationship was found between S-Hg concentrations and total number of amalgam surfaces or total amalgam surface area. These findings may be related to the fact that a significant amount of salivary mercury originates from oral mucosa (40). Considering that the occlusal surfaces of amalgam fillings are in direct contact with oral mucosa, it is logical that they would make a greater contribution to the mercury levels in oral mucosa and, therefore, saliva in comparison to amalgam proximal surfaces.

There is increasing proof that fugitive metals such as mercury play a catalyzing role in the oxidative injury of biological macromolecules. This has led to suppositions that oxidative tissue damage may be related, at least in part, to the toxicity of these metals (11). Previous research has shown that mercury is capable of producing reactive oxygen species (ROS) and leading to changes in the levels of various antioxidants (11,45,46).

As the first biological medium to come into contact with food, drink and material taken in through respiration, as well as the first biological fluid to come into direct contact with mercury leached from amalgam fillings, saliva is the first line of defense against oxidative stress caused by free radicals (47). Our study examined TAA as a representative measure of general antioxidant status. Significant differences were found between salivary TAA (S-TAA) in individuals with amalgams and those without amalgams ($p>0.05$). Moreover, a positive correlation was found between S-Hg levels and S-TAA ($p<0.05$). However, no significant relationship was found between S-TAA and number of amalgam fillings, number of amalgam surfaces, amalgam occlusal surface area or total amalgam surface area ($p>0.05$).
Studies in the literature examining the effects of mercury in amalgam fillings on antioxidants have looked mainly at plasma, (4,21,48) with only 2 studies focusing on salivary antioxidant mechanisms (19,20).

Studies by Pizzichini et al used the FRAP (ferric reducing ability of plasma) method to determine the S-TAA levels in 34 individuals with and without amalgam fillings, examining each amalgam surface to come up with an "amalgam score". S-TAA scores of participants were found to be randomly distributed between 85-393. Neither study found any statistically significant relationship between S-TAA and number of amalgams, amalgam score or S-Mg levels among male participants; however, significant negative correlations were found between S-TAA and these parameters among female participants. Moreover, it was suggested that even very slight increases in S-Hg levels were enough to lead to significant decreases in TAA among women (19,20).

A comparison between the present study and that of Pizzichini et al (19,20) shows that some parameters are analogous whereas others conflict. Differences in findings may be due to the fact that the earlier research failed to take into consideration factors that may affect salivary antioxidant status, such as smoking and periodontal health. Moreover, the connections found by Pizzichini et al between amalgam scores and S-TAA may have been influenced by the relatively subjective method used to evaluate amalgam scores and the differences in methodology between the two studies.
In recent years, antioxidant defense systems have been shown to play an important role in human health. Similar-

ly, amalgam fillings, which are frequently used in treating posterior teeth, have been shown by many studies, including the present study, to have an effect on salivary mercury levels. Future studies are needed to examine the role of mercury found in amalgam fillings in the production of free radicals in saliva and the effects of mercury from amalgam fillings on total antioxidant activity and on specific enzymes and molecules such as uric acid, peroxidase and SOD.

CONCLUSIONS

- Salivary mercury levels among individuals with amalgam restorations are significantly higher than among individuals without amalgam restorations.
- In individuals with amalgam fillings, there is a significant relationship between salivary mercury levels and both the number of fillings and the occlusal surface area of amalgams; however, there is no statistically significant relationship between salivary mercury levels and the number of amalgam surfaces or total amalgam surface area.
- Salivary Total Antioxidant Activity is higher among individuals with amalgam restorations than among those without amalgam restorations; however, the difference between the two groups is not statistically significant.
- There is a significant, positive correlation between salivary mercury levels and salivary Total Antioxidant Activity.
- A positive but statistically insignificant correlation exists between salivary Total Antioxidant Activity and number of amalgam restorations, number of amalgam surfaces, total amalgam surface area and amalgam occlusal surface area.

REFERENCES

1)Hanson M, Pleva J. The dental amalgamissue.A rewiew experiential. 1991; 47: 9-22.

2)Robin A. Mercury toxicity and treatment :a rewiew of the literature.J of Eviromental and Public health. 2012; 2012: 460-508.

3)Ganss C, Gottwald B, Traenckner I, Kupfer J, Eis D, Mönch J, Gieler U, Klimek J.relation between mercury concentrations in saliva , blood and urine in subject with amalgam restorations. Clin Oral İnvest. 2000; 4: 206-2011.

4)Pizzichini M, Fonzi M, Giannerini F,Mencarelli M, Gasparoni A, Rocchi G,Kaistas V, Fonzi L. Influence of amalgam fillings on Hg levels and total antioksidant activity in plasma of healty donors.Sci Total Environ. 2003; 301: 43-50.

5)Factor-Livack P, hasselgren G, Jacobs D, Begg M, Kline J, Gerier J, Mervish NSchenholtz S, Graziona J. Mercury derived from dental amalgams and neurophsychologic function. Environ Helth Perspect. 2003; 111: 719-723.

6)Sandborgh-Englund G, Elinder CG, Langworth S, Schutz A, Ekstrand J. Mercury in biological fluids after amalgam removal. J Dent Res. 1998; 77: 615-624.

7)Aydın N, Karaoglanoglu S, Yigit A, Keles MS, Kırkpınar İ, Seven N. Neuropsychological effects of low mercury exposure in dental staff Erzurum, Turkey. Int Dent J. 2003; 53: 85-91.

8)Jennifer D ,Zwicker E, Daniel J Dutton and John Charles Herbert Emery. Longitudinal analysis of the association between removal of dental amalgam, urine mercury and 14 self-reported health symptoms. Environmental Health. 2014; 3: 1-11.

9)Siedlikowski M, bradly M, Kubow S,Goodrich J, Franzblau A, Basu N M. Bioaccessibility and bioavailability of methylmercury from seafood commonly consumed in North America: In vitro and epidemiological studies.Eviromental Research. 2016; 149: 266-273.

10)Soussa E, Shalaby Y, Maria A M, Maria O M. Evaluation of oral tissue response and blood levels of mercury released from dental amalgam in rats.Archives of Oral Biol. 2013; 58: 981-988.

11)Stohs SJ, Bagchi D. Oxidative mechanisms in the toxicity of metal ions. Free Radical Biol Med. 1995; 18: 321-336.

12)LeBel CP, Bondy SC. Oxygen radicals: common mediators of neurotoxicity. Neurotoxicol Teratol. 1991; 13: 341-346.

13)Miller NJ, Rice-Evans C, Davies MJ. A new method for measuring antioxidant activity. Biochem Soc Trans. 1993; 21: 95.

14)Elia AC, Dörr AJM, Mantilacci L, Galarini R. Effects of mercury on glutathione and glutathione-dependent enzymes in catfish (Ictalurus melas R.); in Mackert B, Friese K, Trace Elements-Their Distribution and Effects in the Environment: Trace Metals in the Environment, Vol 4. Amsterdam: Elsevier Science, 2000.

15)Lund BO, Miller DM, Woods JS. Mercury-induced H2O2 formation and oxidative stres in vivo and in vitro in rat kidney mitochondria. Biochem Pharmacol. 1993; 45: 2017-2024.

16)Gstraunthaler G, Pfaller W, Kotanko P. Glutathione depletion and in vitro lipid peroxidation in mercury or maleate induced acur renal failure. Biochem Pharmacol. 1983; 32: 2969-2972.

17)Molin M, Bergman B, Marklund S, Schütz A, Skerfving S. The influence of dental amalgam placement on mercury, selenium and glutathione peroxidase in man. Acta Odontol Scand. 1990; 48: 287-295.

18)Molin M, Marklund SL, Bergman Bo, Nilsson B. Mercury, selenium, and glutathione peroxidase in dental personel. Acta Odontol Scand. 1989; 47: 383-390.

19)Pizzichini M, Fonzi M, Sugherini L, Fonzi L, Gasparoni A, Comporti M, Pompella A. Release of mercury from dental amalgam and its influence on salivary antioxidant activity. Sci

Total Environ. 2002; 284: 19-25.
20)Pizzichini M, Fonzi M, Sugherini L, Fonzi L, Comporti M, Gasparoni A, Pompella A. Release of mercury from dental amalgam and its influence on salivary antioxidant activity. Bull Group Int Rech Sci Stomatol Odontol. 2000; 42: 94-100.
21)Pizzichini M, Fonzi M, Gasparoni A, Mencarelli M, Rocchi G, Kaistas V, Fonzi L. Influence of amalgam fillings on Hg levels and total antioxidant activity in plasma of healty donors. Bull Group Int Rech Sci Stomatol Odontol. 2001; 43: 62-67.
22)Qujeq D, Hidari B, Bijani K, Shirdel H. Glutathione peroxidase activity and serum selenium concentration in intrinsic asthmatic patients. Clin Chem Lab Med. 2003; 41: 200-202.
23)Canbay Eİ, Çelik K, Kunt T, Ertemur M, Canbay E. Larinks kanserli hastalarda glutatyon peroksidaz aktivitesi ve lipid peroksidasyon düzeylerindeki değişiklikler. Cumhuriyet Üniversitesi Tıp Fakültesi Derg. 2002; 24: 175-178.
24)Brock GR, Butterworth CJ, Matthews JB, Chapple ILC. Local and systemic total antioxidant capacity in periodontitis and health. J Clin Periodontol. 2004; 31: 515-521.
25)Guemouri L, Artur Y, Herbeth B, Jeandel C, Cuny G, Siest G. Biological variability of superoxide dismutase, glutathione peroxidase, and catalase in blood. Clin Chem. 1991; 37: 1932-1937.
26)Queiroz ML, Pena SC, Salles TS, Capitani EM, Saad ST. Abnormal antioxidant system in erythrocytes of mercury-exposed workers. Human Exp Toxicol. 1998; 17: 225-230.
27)Sallsten G, Thoren J, Barregard L, Schütz A, Skarping G. Long-term use of nicotin chewing gum and mercury exposure from dental amalgam fillings. J Dent Res. 1996; 75: 594-598.
28)Barregard L, Sallsten C, Jarvholm B. People with mercury uptake from their own dental fillings. Occup Environ Med. 1995; 52: 124-128.
29)Isacsson G, Barregard L, Selden A, Bodin L. Impact of nocturnal bruxism on mercury uptake from dental amalgam. Eur J Oral Sci. 1997; 105: 251-257.
30)Diab-Ladki R, Pellat B, Chahine R. Decrease in the total antioxidant activity of saliva in patients with periodontal diseases. Clin Oral Invest. 2003; 7: 103-107.
31)Tulunoğlu O, Demirtaş S, Tulunoğlu I. Total antioxidant levels of saliva in children related to caries, age and gender. Int J Paediatr Dent. 2006; 16: 186-191.
32)Bayındır YZ, Polat MF, Seven N. Nitric oxide concentrations in saliva and dental plaque in relation to caries experience and oral hygiene. Caries Res. 2005; 39: 130-133.
33)WHO. Elemental Mercury And Inorganıc Mercury Compounds: Human Health Aspects. Concise International Chemical Assessment Document 50, Geneva, WHO 2003.
34)Svare CW, Peterson LC, Reinhardt JW, Boyer DB, Frank CW, Gay DD, Cox RD. The effect of dental amalgams on mercury levels in expired air. J Dent Res. 1981; 60: 1668-1671.
35)Vimy MJ, Lorscheider FL. Intra-oral air mercury released from dental amalgam. J Dent Res. 1985; 64: 1069-1071.
36)Berlin M, Nordberg G, Serenius F. On the site and mechanism of mercury vapor. Arch Environ Health. 1969; 18: 42-50.
37)Monaci F, Bargagli E, Bravi F, Rottoli P. Concentrations of major elements and mercury in unstimulated human saliva. Biol Trace Element Res. 2002; 89: 193-203.
38)Björkman L, Sandborgh-Englund G, Ekstrand J. Mercury in saliva and feces after removal of amalgam fillings. Toxicol Appl Pharmacol. 1997; 144: 156-162.
39)Mumcu G. İki farklı amalgam dolgu maddesinin tükürükteki civa salınımlarının belirlenmesi ve bunun yüzey alanı genişliği ile olan korelasyonunun değerlendirilmesi. Marmara Üniversitesi Sağlık Bilimleri Enstitüsü, Oral Diagnoz ve Radyoloji ABD, Doktora tezi, İstanbul, 1999.
40)Ekstrand J, Björkman L, Edlund C, Sandborgh-Englund G. Toxicological aspects on the release and sysetmic uptake of mercury from dental amalgam. Eur J Oral Sci. 1998; 106: 678-686.
41)Halbach S. Combined estimation of mercury species released from amalgam. J Dent Res. 1995; 74: 1103-1109.
42)Chapple ILC. Reactive oxygen species and antioxidants in inflammatory diseases. J Clin Periodontol. 1997; 24: 287-296.
43)Monaci F, Bargagli E, Bravi F, Rottoli P. Concentrations of major elements and mercury in unstimulated human saliva. Biol Trace Element Res. 2002; 89: 193-203.
44)Lygre GB, Hol PJ, Eide R, Isrenn R, Gjerdet NR. Mercury and silver in saliva from subjects with symptoms self-related to amalgam fillings. Clin Oral Invest. 1999; 3: 216-218.
45)Elia AC, Dörr AJM, Mantilacci L, Galarini R. Effects of mercury on glutathione and glutathione-dependent enzymes in catfish (Ictalurus melas R.); in Mackert B, Friese K, Trace Elements-Their Distribution and Effects in the Environment: Trace Metals in the Environment, Vol 4. Amsterdam: Elsevier Science, 2000.
46)Zaman K, Pardini RS. An overwiev of the relationship between oxidative stres and mercury and arsenic. Toxic Subst Mech. 1996; 15: 151-181.
47)Marcozzi G. A rapid procedure for the purification of human salivary peroxidase. Biomed Chromatogr. 1996; 10: 97-98.
48)Molin M, Marklund S, Bergman B, Bergman M, Stenman E. Plasma-selenium, glutathione peroxidase in erythrocytes and mercury in plasma in patients allegedly subject to oral galvanism. Scand J Dent Res. 1987; 95: 328-334.