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Increased Microleakage of Amalgam Restorations after Exposure to 2.4 Ghz Radiofrequency Electromagnetic Fields from Common Wi-Fi Routers

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Abstract

Statement of Problem: Previous studies have shown that exposure of dental amalgam fillings to MRI and mobile phones can increase microleakage of amalgam restorations.

Objectives: The aim of this study was to evaluate the effects of exposure to radiofrequency radiation emitted from indoor Wi-Fi access devices on microleakage of amalgam restorations.

Materials and Methods: Standard class V cavities were prepared on the buccal surfaces of 69 extracted human premolar teeth. The samples were divided into two exposure groups and one non-exposed control group of 23 teeth each. The specimens in the experimental groups were exposed to a radiofrequency (RF) radiation emitted from a commercial 2.4 GHz Wi Fi router. The distance between the Wi-Fi router and samples was 30 cm and the router was exchanging data with a laptop computer that was placed 20 m away from the router. Teeth samples in the first exposure group (group A) were exposed to RF for 3 days while the second exposure group (group B) was exposed for 6 days. Then the teeth were sectioned and scored for microleakage under a stereomicroscope.

Results: The score of microleakage was significantly higher in the exposure group A compared to that of the control group. However, the score of microleakage was not significantly different between the exposure group B and control group. Furthermore, the scores of microleakage was significantly higher in the exposure group A than that of the exposure group B.

Conclusions: Exposure of patients with amalgam restorations to radiofrequency waves emitted from commercial Wi-Fi routers can lead to increased microleakage of amalgam restorations.

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Introduction

Dental amalgam has been used widely for more than 150 years for restoring posterior teeth. Dental amalgam has many advantages such as easy manipulation, low technique sensitivity, highly wear resistance, low cost, durability and insolubility in oral fluids [1-3]. However, one of the drawbacks of amalgam restorations is lack of chemical adhesion to the tooth structure which can result to amalgam microleakage. Microleakage is defined as the penetration of microorganisms and toxins between the restoration and walls of cavity preparation. Microleakage can lead to tooth discoloration around the margins of restorations, postoperative sensitivity, secondary caries, restoration failure, pulpal pathology and partial or total loss of restoration [1, 4-5].

Wi-Fi is a local area wireless computer networking technology which allows electronic devices to network using Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards. These standards mainly use the 2.5 gigahertz (12 cm) UHF and 5 gigahertz (6cm) SHF ISM radio bands [6]. It has been used drastically in houses and public places such as schools and hospitals during recent years [7]. The lower cost and easier deployment of these devices than wired computer networks lead to rapidly increase of Wi-Fi devices [8]. However, this also raised great public concern about the potential adverse effects of exposure to electromagnetic fields (EMFs) emitted from these devices [9].

Over the past years, our team have investigated the effects of exposure to different common and/or occupational sources of EMFs such as cellular phones [10-17], mobile base stations [18], mobile phone jammers [19], laptop computers [20], radars [11], dentistry cavitrons [21] and MRI [22-23]. We have previously shown that exposure of patients with amalgam restorations to radiofrequency radiation emitted from conventional Wi-Fi devices can increase mercury release from amalgam restorations [24]. To the best of our knowledge, this is the first study that aimed to evaluatethe effect of exposure to Wi-Fi signals on the microleakage of amalgam. Therefore, this study is conducted to investigate the microleakage of amalgam following exposure to Wi-Fi signals.

Materials and Methods

Teeth Samples

The present study was approved by the Ethics Committee of Shiraz University of Medical Sciences. Forty-six non-carious recently extracted premolar and molar teeth were selected for this study. The teeth were stored in saline solution for up to 2 months after cleaning and surface debridement. The teeth had any fractures or structural defects were excluded. Standardized class V cavities (3 mm length, 5 mm wide, 2 mm deep) were prepared on the buccal surface at the cementoenamel junction using carbide burs (SS White Burs, Lakewood, NJ) and a high speed turbine with air-water sprayusing a template. A separate bur was used after every 6 cavity preparations to ensure cutting efficiency. The cavities were restored with Cinalux (non-gama-2, spherical amalgam, Faghihi Dental, Tehran, Iran) amalgam. The amalgams were triturated according to manufacturers' directions, and then they were condensed incrementally towards the cavity walls using small condensers. All the procedures for restoration of the cavities including cavity preparation, burnishing, and polishing were performed by the same clinician. The restored teeth were placed in saline solution at 37° until they were exposed. The teeth were randomly divided into 3 groups each containing 23 teeth.

Exposure Setup

The specimens in the exposure groups were exposed to radiofrequency radiation emitted from a commercial 2.4 GHz Wi-Fi router (Dlink, Taiwan). The distance between the Wi-Fi router and samples was 30 cm and the router was exchanging data with a laptop computer that was placed 20 m away from the router during the whole exposure phase. The exposure group A was exposed to radiofrequency radiation emitted from standard Wi-Fi devices for 3 days. The second exposure group (B) was exposed for 6 days at the same condition. The control group was kept outside the experiment room.

Microleakage evaluation

Two layers of nail varnish were applied to the entire teeth surfaces except for the restorations and 1 mm ar-

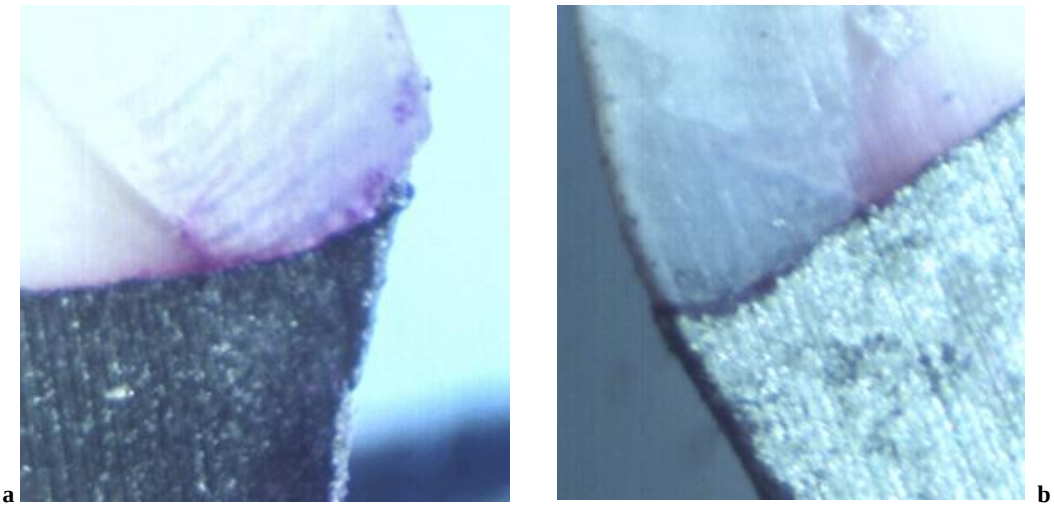

Figure 1a: Dye penetration through enamel, passing DEJ to dentin (score 3) in a sample tooth **b:** No Dye leakage (score 0) in a control tooth

ound them. The specimens were immersed in 2% basic fuchsin dye solution (merck, Germany) at the room temperature for 24 hours and then they were rinsed in tap water and dried. A slow speed water cooled saw was used to section each tooth buccolingually. The section corresponding to the central portion of the tooth restoration was examined at the gingival, axial and occlusal margins under a stereomicroscope (Olympus. Tokyo, Japan) at 80× magnification by the examiner who was blinded to the groups. The degree of microleakage was evaluated according to a standard ranking in which [6] 0= No dye penetration; 1= Dye penetration along the enamel; 2= Dye penetration along the dentine-enamel junction (DEJ) but not including the axial wall and 3= Dye penetration along the axial wall. (Figure 1a and b)

The data were analyzed using the Kruskal-Wallis test and the Mann-Whitney U-test to compare microleakage in the case and control groups to identify any statistically significant differences at the significance level of 0.95(p <0.05).

Results

The distribution of the scores of microleakage in each group is presented in Table 1. The score of microleakage was significantly higher in the exposure group A than that of the control group (p =0.03). The percent of the teeth with grade 3 microleakage in the exposure group A was 10.5 %, while this percent was zero in the control group. The scores of microleakage was not significantly different between the exposure group B and control group (p =0.82). The scores of microleakage was significantly higher in the exposure group A than the experimental group B (p =0.04). The percent of the teeth with grade 3 in the exposed group A was approximately 3 times more than the exposure group B. Furthermore, the percent of the teeth with grade 1 in the exposed group A was 26.3 %, while this percent was 7.4 in the group B.

Discussion

The present study suggested that exposure to 2.4 GHz radiofrequency radiation emitted from commercial Wi-Fi devices can increase the microleakage of amalgam restorations. The score of microleakage was significantly higher in the exposure group A compared to that of the control group and the score of microleakage in the exposure group A was also significantly higher than that of the exposure group B.

There are few studies which evaluated the effects of electromagnetic radiations on microleakage of amalgam restorations [25-28]. Some studies successfully showed that the electromagnetic fields were capable of increasing the microleakage of amalgam restorations [26-27]. Moreover, we have recently found that X-ray exposure can increase the microleakage of amalgam restorations [29]. Similarly, we showed that exposure of the teeth samples with amalgam restora

Table 1: The distribution of the scores in the control and Wi-Fi exposure groups

Group	Percent(%) of the scores				Mean rank	*p* value*
	0	1	2	3		
Control group	82.6	13	4.3	0	42.45[a]	0.046
3 days Wi-Fi exposure group(A)	52.6	26.3	10.5	10.5	31.63[b]	
6 days Wi-Fi exposure group(B)	81.5	7.4	7.4	3.7	32.63[a]	

*: Kruskal-Walis test
Mean rank values with different letters in superscript were statistically different. (Mann-Whitney U test)

ons to either electromagnetic fields produced by light cure devices or those generated by mobile phones can lead to increased microleakage of amalgam restorations [30]. Interestingly, it was also shown that exposure of the amalgam restorations to both of these radiations (light cure + mobile phone) induces a synergistic response which further increases the microleakage of amalgam restorations. The results of these studies are generally in line with the findings of our current study. Interestingly, the source of exposure in both of these studies was MRI. It is worth noting that in MRI, teeth samples are exposed to static magnetic field, gradient magnetic field and radiofrequency radiation. Shahidi et al. have suggested that the increase in microleakage following MRI might be attributed to the thermoelectromagnetic convection induced by exposure to EMFs that was supposed to be responsible for the enhancement of the diffusion process, grain boundary migration and vacancy formation resulting in microleakage [31]. However, Mortazavi and Paknahad believed that the magnitude of temperature increase is not high enough to justify this theory [32]. However, Akgun et al. concluded that MRI does not increase the microleakage of dental amalgam [25]. Mortazavi et al. evaluated the effect of PEMFs on microleakage of amalgam restorations, using a pair of Helmholtz coils. They suggested that exposure to pulsed electromagnetic fields (PEMF) does not cause adverse effects on microleakage of amalgam restorations [24]. We believe that this difference can be due to different exposure patterns. On the other hand, our team has previously reported that exposure to pulsed electromagnetic fields generated by Helmholtz coils could not cause adverse effects on microleakage of amalgam restorations. This disagreement can be simply explained by the differences in the frequency of RF radiation in MRI studies and the operating frequency of Helmholtz coils that was 50 Hz. The importance of this frequency-dependent phenomenon should be further investigated by future studies.

Conclusion

To our knowledge, this is the first study which addresses the effect of exposure to Wi-Fi signals on microleakage of amalgam restorations. Altogether, the findings of this study showed that exposure to radiofrequency radiation emitted from Wi-Fi devices may result in increased microleakage of amalgam. Considering the significance of this challenging finding, further *in vitro* and *in vivo* studies are needed to better understanding the role of exposure to electromagnetic fields generated by widely used sources of these fields such as mobile phones, cordless phones or Wi-Fi on microleakage of dental amalgam fillings.

Conflict of Interest: None declared.

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