Microleakage of Amalgam Restorations after Exposure to Electromagnetic Fields of a Commercial Hair Dryer: An *Ex-Vivo* Study

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ABSTRACT

Background: Dental amalgam is a popular restorative material used in posterior teeth. Hair dryers can emit electromagnetic fields (EMFs) that may affect the microleakage of the amalgam-tooth interface.

Objective: The aim of this experimental study was to investigate whether the EMFs produced by commercial hair dryers could cause microleakage in amalgam restorations.

Material and Methods: In this experimental study, a total of 100 human extracted teeth without cavities were selected and prepared for class V preparations on their buccal aspects. The teeth were divided into five groups (G1–G5), each containing 20 teeth. Group 1 served as the control group and was not subjected to any treatment. Groups 2 to 5 were exposed to EMFs of a hair dryer (2000 W, 220 V, and 50 Hz). Groups 2 and 3 were exposed to "EMFs +Hot Air" for 20 min at 10 cm and 30 min at 5 cm, respectively. Groups 4 and 5 were exposed to "EMFs +Cool Air" for 20 min at 10 cm and 30 min at 5cm, respectively. After preparation, the sectioned teeth were evaluated for microleakage using dye penetration measurement.

Results: The microleakage scores showed a significant difference among the three exposure groups (G2, G3, and G5) and the control group (*P*=0.001, 0.002, and 0.01, respectively). However, there was no significant difference between G4 and G1. The microleakage score in G2 was higher than that in G4.

Conclusion: This study suggests that the common use of hair dryers can lead to damage in amalgam restorations.

Keywords
Electromagnetic Fields; Dental Leakage; Dental Amalgams

Introduction

The most commonly used dental material is a dental amalgam for posterior teeth restorations. This filling material was widely used for restoring posterior teeth because of its convenience of manipulation, low technique sensitivity, high wear-resistant, more affordable than alternative materials, durability, and being insoluble in oral fluids [1-4]. However, as a cause of microleakage, the absence of chemical adhesion to the dentin and enamel is one of the most significant disadvantages of amalgam filling materials. As a definition, the entry of microbial germs and their secretions in intervals of the amalgam material and the prepared dental wall is known as microleakage. In addition to tooth discoloration at the restoration's margins, microleakage may cause subsequent decay, failure of filling materials, sensitivity, pulpal injury, and partial or complete restoration loss [1, 5, 6].

Extremely Low-frequency Electromagnetic Fields (ELF-EMF) and Radiofrequency Electromagnetic Fields (RF-EMF) are just two types of electromagnetic fields. However, electrical power sources and appliances create ELF-EMFs (3 Hz to 3,000 kHz) and wireless gadgets, including mobile phones and other communication devices like radars emit RF-EMFs (10 MHz to 300 GHz) [7, 8].

Hair dryers are common household devices used to quicken the evaporation of water and dry hair, by directing a stream of cool, warm, or hot air toward humid hair [9]. The majority of hairdryers include a label with a power output to show their maximum power (Wattage), which varies between 800 and 1800 Watts. The mode, in which a hair dryer runs, determines how much energy it uses. Typically, hair dryers consume electricity in the range of 1,500 to 2,000 watts (W), which is dependent on the specific model. These devices usually use 15 to 20 amps and require a 120/220 volt outlet for connectio [10].

Every electrical appliance in our home emits electromagnetic fields. An electrical appliance that is plugged in produces an electric field even during turned off. An electrical device also emits a magnetic field during turned on (the electrical current is flowing) [11].

Since a lot of power is used, and the motor or heater is typically held quite close to the user's head, the Electromagnetic Fields (EMFs) of electrical devices, like hair dryers and wireless signals, may cause public anxiety because of their negative consequences possibilities [12]. As reported by WHO, even similar devices produce different levels of magnetic fields. In this light, the WHO states that the strength of the magnetic fields produced by some hair dryers can reach very high levels [13]. In recent years, attention has extended to examining the health threats of various tools that EMFs, like smartphones. [14-22], stations for mobile devices [23], cellular phone jammer equipment [23], laptops [24, 25], radars [26], cavitron instruments in dental offices [27], and magnetic resonance imaging devices [28, 29].

Keshavarz et al. recently conducted a study on the effects of various physical stresses on microleakage and mercury released in harmful amounts in amalgam materials and also investigated the effect of a broad range of stressors, including Magnetic Resonance Imaging (MRI) as Static Magnetic Fields (SMF) and mobile phones as Electromagnetic Fields (EMF) producing devices, ionizing radiation, like X-rays, and lasers as non-ionizing radiation [30].

The present study is the first investigation of the effect of the magnetic fields emitted by commercial hair dryers on the microleakage of dental amalgam restorations.

Material and Methods

Teeth Samples

In this experimental study, one hundred non-carious extracted premolars and molars were selected without any fractured or damaged teeth. Following debridement and washing of the teeth with distilled water, they were immersed in a saline solution and kept there for two months. Class V restorative cavities with standard size (3 mm length, 5 mm width, and 2 mm depth) were prepared on the buccal aspects of the teeth just in their Cement-enamel Junction (CEJs) using a template by carbide burs (SS White Burs, Lakewood, NJ). It's worth mentioning, after every six cavity preparation, a fresh bur was used to ensure cutting effectiveness. Next, the high copper spherical amalgam (Cinalux, Faghihi Dental, Tehran, Iran) was used to fill the preparative cavities in all samples. The amalgams were incrementally applied and condensed, by using small condensers, against the preparation walls after being triturated following the manufacturer's instructions. Burnishing was then completed by an ovoid shaped burnisher. The identic dentist carried out the all steps of restoration. The restored teeth were kept for seven days in distilled water at 37 °C.

Exposure of the samples

All restored teeth were divided into 5 groups; G1 to G5 with 20 restored teeth in each group. In addition, the control group as G1 group was not exposed to EMFs, while all samples in G2 to G5 groups were subjected to electromagnetic fields created by a commercial hair dryer (2000 W, 220 V, and 50 Hz) under the following hairdryer's modes: G2 and G3 for hot air mode for 20 and 30 min at a distance of 10 and 5 cm, respectively; G4 for cold air mode for 20 min at a distance of 10 cm, and G5 for cold air mode for 30 teeth.

A calibrated EMF meter was used to control the exposure setup. During exposure, the environment temperature was controlled by a calibrated thermometer. The teeth at the end of 5 ml Eppendorf were placed in the circular pattern surrounding the hairdryer device to ensure uniform irradiation. Further, a microleakage was evaluated.

Microleakage evaluation

Excluding the amalgam fillings and their 1-mm surrounding, all of the teeth surfaces received two coats of nail varnish. In all groups, the restored teeth were soaked in 2% basic fuchsin dye solution (Merck, Germany) for 24 h at 25 °C, washed with tap water, and dried. Following that, each tooth was buccolingually cut into two sections using a slow-moving saw with air and water-cooling.

An interpreter, who was unaware of the groups, examined the gingival, axial, and occlusal margins of the segment corresponding to the central area of the tooth restoration using a stereomicroscope (Olympus, Tokyo, Japan). The degree of microleakage was assessed using a standardized ranking method [6], in which 0, 1, and 3 denote no dye infiltration, dye passage anywhere along enamel, dye entry on the Dentine-enamel Junction (DEJ), but not across the axial wall, respectively. Moreover, 3 shows dye permeability along an

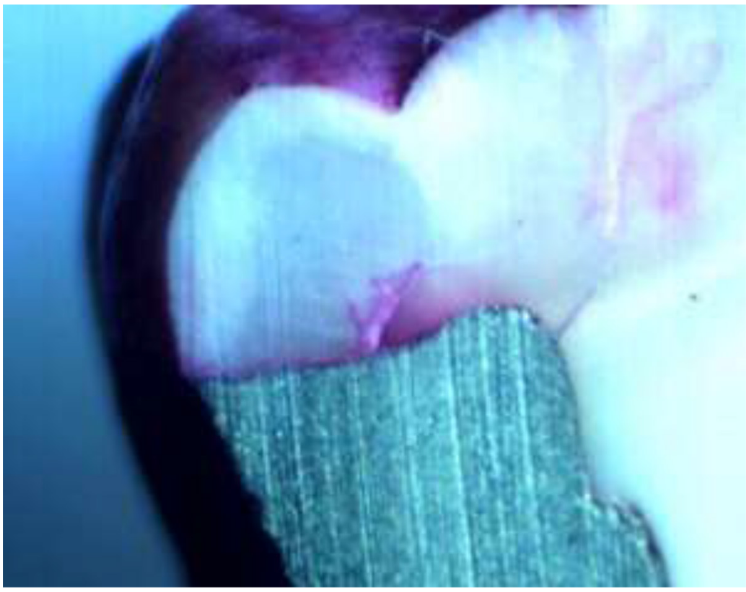

Figure 1: Microleakage evaluation under stereomicroscope shows a dye penetrating the enamel and spreading through the dentine-enamel junction (DEJ) to the dentin (score 3)

axial wall (Figures 1-2).

At the statistical significance of 0.95 (*P*-value<0.05), the Kruskal-Wallis test and the Mann-Whitney U-test were conducted to assess the data and identify any statistically significant association between the experimental and control groups for microleakage.

Results

Table 1 displays the distribution of each group's microleakage scores. A total of 12.5% of teeth in G2 and 5.0% in G3 had a grade 3 score, while the percentage of teeth with a grade 3 microleakage score was zero in the control group, G4, and G5. Also, the microleakage with grade 2 in G2, G3, and G5 groups was 5.0%, 5.0%, and 3.6%, respectively, while it was 0% in G4 and the control group.

Significantly more microleakage occurred in the G2, G3, and G5 groups than in the control group (*P*-value=0.001, 0.002, and 0.01). However, the difference between the scores of

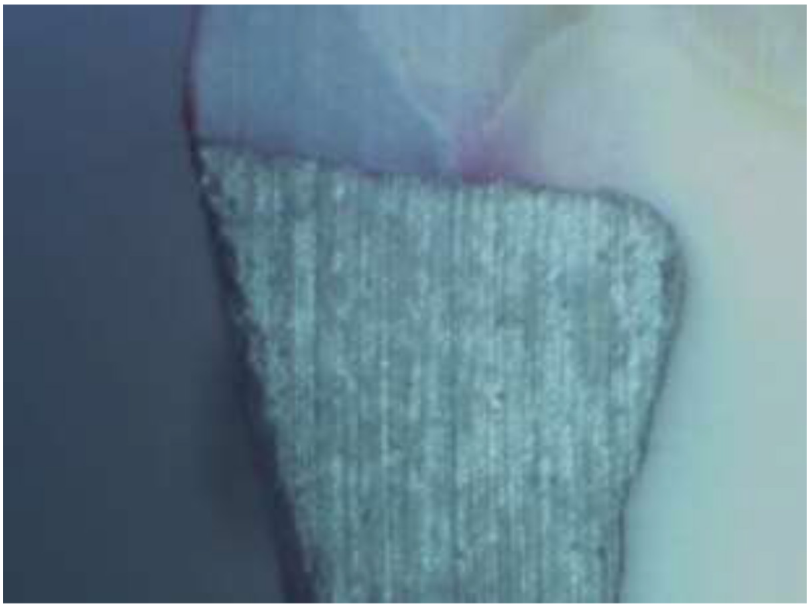

Figure 2: A sample control tooth under stereomicroscope microleakage evaluation reveals no dye penetration (Score 0)

Table 1: The summary of the grades in the control and radiofrequency heating and electromagnetic exposure groups

Group	EMF	Heat	Distance (cm)	Exposure Time (min)	Percent (%) of the scores				Mean rank	**P*-value
					0	1	2	3		
G1					90.0	10.0	0.0	0.0	71.90	0.003
G2	√	√	20	10	57.7	25.0	5.0	12.5	104.06	
G3	√	√	30	5	60.0	30.0	5.0	5.0	99.75	
G4	√	No	20	10	25.0	7.0	0.0	0.0	81.88	
G5	√	No	30	5	18.0	9.0	1.0	0.0	94.34	

*Kruskal-Walis test
EMF: Electromagnetic Field

microleakage in G4 and the control group was not statistically significant (*P*-value=0.167).

The microleakage scores in G2 were significantly higher than in G4 (*P*-value=0.033). However, these scores were not substantially higher than G3 and G5 (*P*-value=0.623, 0.338). The microleakage degree of G3 was not significant compared with those of G4 and G5 (*P*-value=0.71 and 0.591, respectively). The microleakage scores between G4 and G5 didn't have a significant difference statistically (*P*-value=0.215) (Table 2).

Table 2: The *P*-values in comparing all of the groups according to the Mann-Whitney U-test

Groups	G1	G2	G3	G4	G5
G1		0.001	0.002	0.167	0.01
G2			0.623	0.033	0.338
G3				0.71	0.591
G4					0.215

Discussion

The current study showed that amalgam restorations cause greater microleakage when exposed to EMFs produced by commercial hair dryers. Some previous studies showed an increase in microleakage of dental amalgam restoration after exposure to the MRI's electromagnetic fields [31, 32]. On the contrary, Akgun OA et al. could not detect any significant difference between whether the dental amalgam samples were exposed to MRI's electromagnetic fields or not, in the scores of microleakage [33].

Amalgam microleakage was significantly higher in the exposed group to a hairdryer than in the control group. According to Shahidi et al. [32], the thermoelectromagnetic convection brought on by exposure to EMFs can increase microleakage after MRI. The intensification of the diffusion process, grain boundary migration, and void formation resulting in microleakage were all attributed to this convection. However, the rate of rising temperature induced by EMFs was insufficient to support their theory [34].

To the best of our knowledge, this is the first study that investigates the effect of exposure to electromagnetic fields of commercial hair dryers on the microleakage of dental amalgam restorations. It should be noted that hair dryers are widely used in hair salons and homes. On the other hand, many people have some amalgam dental fillings in their oral cavities. Therefore, this present study can clarify some of the foggy aspects of the complicated questions about the rise in microleakage from dental amalgam restorations. Regarding the results of this study, it can be suggested that populations with wide amalgam restorations should limit hairdryer use.

Although it can be concluded that frequent everyday use of hairdryers can lead to damaged amalgam restorations, providing the significance of these findings, additional *ex-vivo* and *in vivo* research is required to fully understand the mechanisms of EMFs-induced damages.

Conclusion

According to this study, the frequent use of hair dryers may cause damage to amalgam restorations. Although the findings suggest that individuals with wide amalgam restorations should limit their use of hair dryers, more research, both *ex-vivo* and *in vivo*, is needed to fully understand the mechanisms of damage caused by EMFs. Therefore, clinicians should be mindful of the potential impact of hair dryers on dental amalgam restorations and advise their patients accordingly. While the study concludes that everyday use of hair dryers can be detrimental to amalgam restorations, further research is required to confirm the significance of these findings.

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Authors' Contribution

The study was conceived and designed by SMJ. Mortazavi and M. Paknahad. Data collection and analysis were performed by I. Khaleghi and M. Eghlidespour. The article was written by M. Paknahad and SMJ. Mortazavi. All authors reviewing, revising, and approving the final manuscript.

Ethical Approval

This work was approved by the Shiraz University of Medical Sciences Ethics Committee (IR.SUMS.REC.1395.S402).

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Conflict of Interest

SMJ. Mortazavi, as the Editorial Board Member, was not involved in the peer-review and decision-making processes for this manuscript.

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