ORIGINAL RESEARCH

Effect of Mobile Phone with and without Earphones Usage on Nickel Ion Release from Fixed Orthodontic Appliance

Ramya Rajendran[1], Sudhakar Venkatachalapathy[2], Balavignesh Thiyagarajan[3], Sruthi Jeevagan[4], Anandadevi Chinnasamy[5], Muruganandam Sivanandham[6]

Abstract

Introduction: This study is an attempt to assess whether the usage of headphones could minimize the nickel ion release from fixed orthodontic appliance compared with hand-held mobile phones. The aim of the study is to validate the hypothesis whether there is a significant variation in nickel ion release from fixed orthodontic appliance among the patients using hand-held mobile phones and patients using mobile earphones.

Materials and methods: This is a cross-sectional study where a total of 60 healthy individuals who were undergoing fixed orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopedics, Adhiparasakthi Dental College and Hospital, Melmaruvathur, Chennai, India, and all these individuals were bonded and banded. All of them are class I malocclusion with bimaxillary protrusion. Salivary samples were collected in their regular checkup after two months and 7th, 14th, and 21st days salivary nickel level was evaluated based on their usage of mobile phones with earphones and without earphones.

Results: In this study, paired and independent *t*-tests were used. On basis of statistics results, the mean of nickel release in both male and female participants using mobile phones without earphones were significantly higher than the participants using mobile phone with earphones.

Conclusion: By our study, we concluded that usage of mobile phones with earphones has a significant reduced effect on metal ion release from fixed orthodontic appliance when compared to usage of mobile phones without earphones.

Keywords: Ear-phones, Fixed orthodontic appliance, Mobile phones, Nickel, Saliva.

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Introduction

Modern dental appliances are often made of three types of materials: metals, resins, and ceramics. As they are designed to function effectively in contact with tissues of the oral cavity throughout the duration of their lifetime, they are categorized as biomaterials and, from a legal perspective, as medical devices. The majority of orthodontic biomaterials interacts with the biological environment; they are not completely inert. The interaction will have an impact on the material quality and may have negative impacts on the individuals. The amount of the effect will determine the material's biocompatibility and safety. Every orthodontic armamentarium contains a significant amount of metal. In the past, silver alloy, gold, platinum, and titanium were utilized in orthodontics. Owing to their ductility, malleability, and other physical characteristics, such alloys were not suitable for intricate machining for different orthodontic mechanics. To address these challenges, stainless steel gained popularity around the field of orthodontics in 1932. Orthodontic brackets, bands, and wires are made of austenitic stainless steel, which includes 8% nickel and 18% chromium. Intra-oral fixed orthodontic appliances are mostly made up of alloys containing nickel, cobalt, and chromium in different percentage.[1] The inherent heterogeneity of each metal alloy, force and function between wires and brackets along with various physical, chemical, and microbial insults in oral cavity largely influence the metal ion release from orthodontic appliances.[2]

Over the past few years the obsessed usage of mobile phones has caused concern because of possible adverse effects from exposure to radio frequency-emitted radiation.[3] Nickel is known to cause frequent hypersensitivity reaction compared with other metals.[4]

Also nickel causes allergic, cytotoxic, mutagenic, and even carcinogenic side effects.[5] Studies have revealed a correlation between mobile phone usage and dose-dependent nickel ion release from fixed orthodontic appliances.[6]

Some studies have concluded that radiations from the mobile phones cause significant increase in salivary oxidative stress, salivary flow rate, total protein and albumin and it also causes decreased enzymatic activity such as amylase.[7] These mobile phones emit radio frequency electromagnetic radiations which cause the harmful effects.[8] Patients undergoing fixed orthodontic treatment might be at serious risk when they are using the mobile phones close proximity to oral cavity during conversation period. This is due to the exposure of metallic appliances to mobile phone radiations causes the release of toxic corrosion products in saliva.

This study is an effort to determine whether the release of nickel ion from orthodontic appliance secondary to mobile phone usage could be limited with the usage of earphone.

[1–6]Department of Orthodontics & Dentofacial Orthopaedics, Adhiparasakthi Dental College & Hospital, Melmaruvathur, Tamil Nadu, India

Corresponding Author: Ramya Rajendran, Department Of Orthodontics, Adhiparasakthi Dental College, Melmaruvathur, Tamil Nadu, Phone: +919003795490, e-mail: ramyaraj2884@yahoo.co.in

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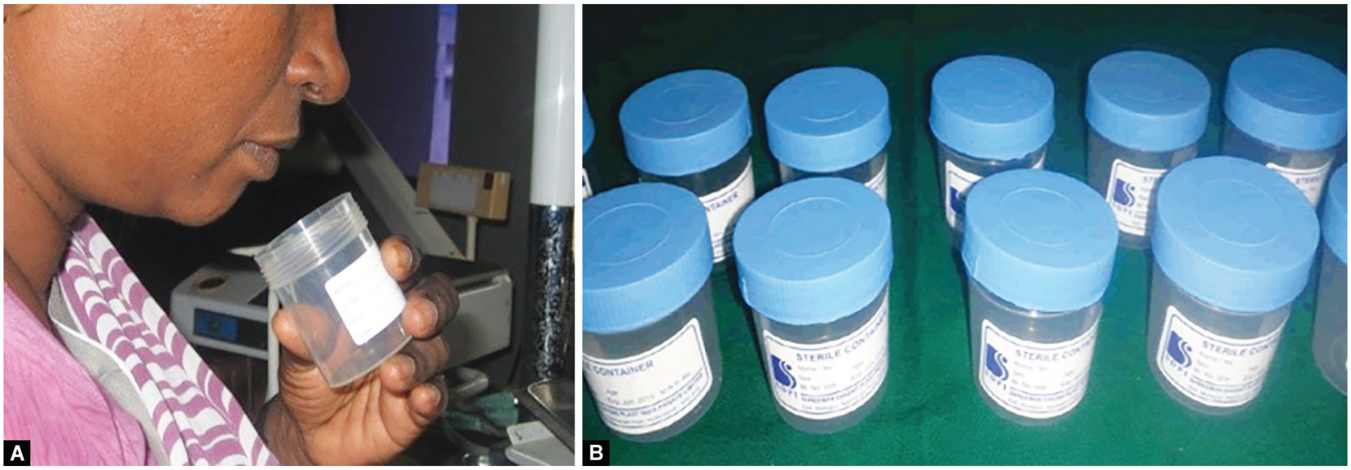

Figs 1A and B: Collection of the saliva after oral hygiene practice (A) Collection of the saliva after oral hygiene practice; (B) Initial sample collection from healthy patients

Materials and Methods

The study was a single-center, randomized controlled trial. A total of 60 healthy individuals (aged 18–25 years) who were undergoing fixed orthodontic treatment for Angle's class I malocclusion with bimaxillary protrusion in the Department of Orthodontics & Dentofacial Orthopaedics, Adhiparasakthi Dental College & Hospital, Melmaruvathur, Tamil Nadu, India, were selected for this cross-sectional study. Ethical clearance was obtained from the research review committee (IRB reference no-2015-MD-Br II-MAN-11/APDCH). Informed consent was obtained from all individuals to participate in this study. The duration of this study was about 3 years (2015–2018). The sample size was determined using G Power 3.0.10.

Selected patients were in the age group of 18–25 years and they were under fixed orthodontic treatment. Based on gender, the participants were categorized into two groups:

1. Group I: 30 male patients undergoing fixed orthodontic treatment and should use mobile phones for 30 minutes per day.
2. Group II: 30 female patients undergoing fixed orthodontic treatment and should use mobile phones for 30 minutes per day.

Inclusion Criteria

- Patients in age group of 18–25 years (both males and females)
- Angle's class I bimaxillary protrusion cases were selected, should be under fixed orthodontic treatment
- Mobile phones with specific absorption rate (SAR) from 0.24 to 0.32 watts/kg
- Mobile phone usage of the participants should be minimum of 30 minutes per day.

Exclusion Criteria

- Patients with any systemic diseases or under any medication
- Patients with smoking or drinking habit
- Patients with any metallic restoration such as amalgam or any fixed prosthesis
- Patient with missing or extracted tooth except third molars that could alter the salivary properties and nickel content of saliva.

We selected the individuals using mobile phones which are bought less than one year and with low SAR and we have standardized this from the reference values within the range of 0.24–0.32 watts/kg.[9]

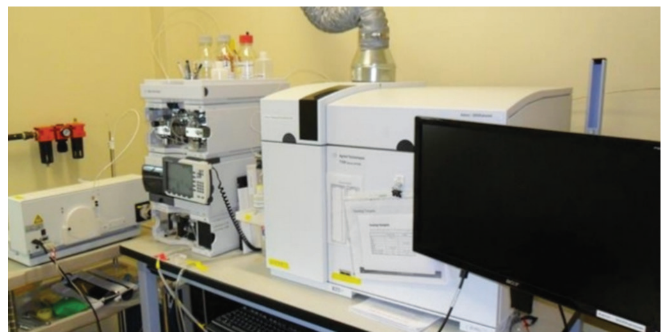

Fig. 2: Inductively coupled plasma-mass spectrometry

Three samples were collected from both groups and compared. First sample is baseline (i.e., after one week of fixed orthodontic treatment), second sample was collected after using only hand-held mobile phones for two weeks, and third sample was collected after using mobile with headphones for next two weeks.

All participants were bonded with 0.022″ Equilibrium 2 MBT (DENTARUM) Prescription brackets. After initial leveling and aligning, all these participants were upgraded to 0.016 Ni-Ti (3M UNITEX ORTHOFORM III ARCH) in both upper and lower arches. And each tooth was secured with 3M UNITEX clear modules.

After one week, both groups were recalled for first sample collection (i.e., baseline). Unstimulated saliva was collected between 9.00 am and 11.00 am by spitting method.[10] Participants were instructed not to eat or drink an hour prior to sample collection. Inductively coupled plasma-mass spectrometry was used to measure the nickel ion levels in the saliva samples as shown in Figure 1.[11] After sample collection, the participants were instructed to use only hand-held mobile phones for the following two weeks and to report again for second sample collection. Then the participants were again strictly instructed to use mobile with headphones for the next two weeks and to report for third sample collection (Fig. 2).

The data obtained were tabulated and subjected to statistical analysis.

Result

Data analysis was performed using SPSS (IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: IBM Corp. Released 2013).

Table 1: Salivary nickel ion levels for group I (30 male patients)

S. no.	*Initial sample 7th day*	*Without earphone 14th day*	*With earphone 21st day*
1	0.79	3.58	3.38
2	1.56	7.73	5.03
3	3.2	4.39	4.04
4	0.40	3.26	–
5	0.98	5.15	3.24
6	0.49	8.55	8.33
7	2.85	5.91	4.40
8	0.36	5.78	5.03
9	0.97	3.18	2.23
10	0.35	4.14	3.78
11	2.68	3.74	3.33
12	0.70	3.92	3.78
13	0.40	–	–
14	0.52	6.32	4.24
15	0.32	7.67	5.77
16	2.21	10.32	8.23
17	0.47	5.47	4.97
18	3.25	–	–
19	0.91	8.37	5.95
20	0.67	5.79	4.84
21	3.45	9.38	7.29
22	0.45	6.34	5.11
23	0.69	7.27	5.69
24	1.82	5.82	4.34
25	0.77	6.96	4.92
26	0.89	4.55	4.10
27	1.23	5.79	3.76
28	0.66	3.56	2.96
29	0.39	6.73	–
30	0.47	7.76	6.13

Table 2: Salivary nickel ion levels for group II (30 female patients)

S. no.	*Initial sample 7th day*	*Without earphones 14th day*	*with earphones 21st day*
1	1.34	3.79	2.54
2	1.14	5.59	3.89
3	1.45	4.25	3.19
4	0.44	4.19	3.28
5	0.75	3.11	2.28
6	2.35	4.34	3.28
7	3.16	4.93	3.39
8	2.45	3.93	–
9	0.57	5.73	4.24
10	0.74	4.43	2.21
11	0.93	5.81	3.72
12	1.17	6.73	4.93
13	1.49	7.54	5.27
14	0.69	5.93	3.32
15	3.76	10.73	8.45
16	5.23	11.51	8.37
17	4.44	9.77	7.63
18	0.32	5.12	3.93
19	0.23	6.21	4.50
20	0.29	4.73	–
21	2.83	3.35	3.19
22	3.64	5.17	4.83
23	1.71	6.73	5.21
24	0.53	5.43	4.84
25	1.93	4.97	4.03
26	0.76	–	–
27	1.32	6.34	4.83
28	2.36	6.98	5.06
29	0.98	3.75	2.48
30	1.78	4.29	3.04

Significance level was fixed as 5% ($\alpha = 0.05$). The normality test Kolmogorov–Smirnov test results revealed that the data followed a normal distribution hence parametric methods were applied.

In group I, the nickel ion level in the first sample ranged from 0.35 to 3.45 ppb (mean 1.2504, SD 1.05124). In the second and third set of samples the values ranged between 3.18–10.32 ppb (mean 6.0716, SD 1.96617) and 2.96–8.33 (mean 4.7776, SD 1.52134), respectively, as shown in Table 1. In group II, the nickel ion level in the first sample ranged from 0.23 to 5.23 ppb (mean 1.7432, SD 1.39836). In the second and third set of samples the values ranged between 3.75–11.51 ppb (mean 5.7608, SD 2.15047) and 2.21–8.45 ppb (mean 4.3220, SD 1.68193), respectively, as shown in Table 2.

Paired sample *t* test was used to compare the nickel ion levels among the three samples in both groups I and II (Tables 3A and 3B). A highly significant difference ($p < 0.001$) in nickel ion level was observed between the first sample and the second sample. This shows that there is significant increase in nickel ion release in saliva with the usage of mobile phones in orthodontic patients. A highly significant difference ($p < 0.001$) in nickel ion level was observed between the second sample and the third sample. This shows that the usage of headphones could significantly reduce the release of nickel ions in saliva compared with using hand-held mobile phones.

Table 3(A): Paired sample *t*-test to compare the mean between different time points in group I

Group	*Variables*	*N*	*Mean*	*SD*	*p-value*
Group I	Initial sample (ppb)	26	1.2504	1.05124	<0.001
	Without earphones, 14th day (ppb)	26	6.0716	1.96617	
	Initial sample (ppb)	26	1.2504	1.05124	<0.001
	With earphones, 21st day (ppb)	26	4.7776	1.52134	
	Without earphones, 14th day (ppb)	26	6.0716	1.96617	<0.001
	With earphones, 21st day (ppb)	26	4.7776	1.52134	

Independent sample *t* test was used to compare the mean values between the two groups (Fig. 3 and Table 4). There was no significant difference in nickel ion release between the male and female participants. Thus, gender has little role in nickel ion release in orthodontic patients.

Table 3(B): Paired sample *t*-test to compare the mean between different time points in group II

Group	*Variables*	*N*	*Mean*	*SD*	*p-value*
Group II	Initial sample 7th day	27	1.7432	1.39836	<0.001
	Without earphones 14th day	27	5.7608	2.15047	
	Initial sample 7th day	27	1.7432	1.39836	<0.001
	With earphones 21st day	27	4.3220	1.68193	
	Without earphones 14th day	27	5.7608	2.15047	<0.001
	With earphones 21st day	27	4.3220	1.68193	

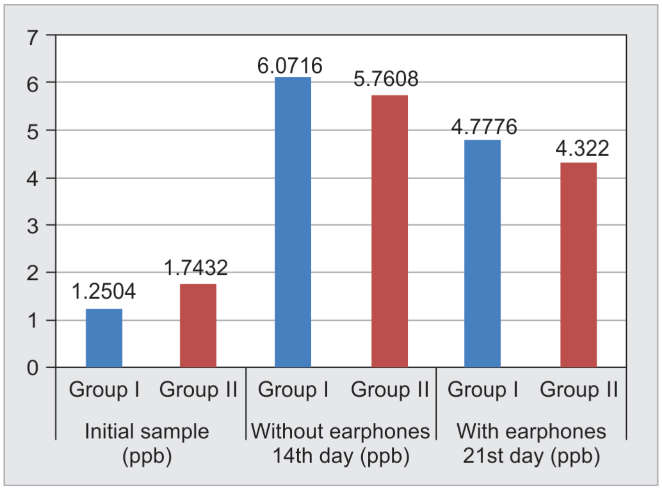

Fig. 3: Five independent samples *t*-test to compare mean values between group I and group II

Table 4: Independent samples *t*-test to compare mean values between group I and group II

Variables	*Group*	*N*	*Mean*	*SD*	*p-value*
Initial sample (ppb)	Group I	26	1.2504	1.05124	0.165
	Group II	27	1.7432	1.39836	
Without earphones 14th day (ppb)	Group I	26	6.0716	1.96617	0.596
	Group II	27	5.7608	2.15047	
With earphones 21st day (ppb)	Group I	26	4.7776	1.52134	0.320
	Group II	27	4.3220	1.68193	

Discussion

In the last two decades, mobile phones have changed the way we live our life. The electromagnetic radiation emitted from mobile phone is nonionizing in nature in the range of 900–1800 MHz. The absorption of these radiation by the water content in the tissues results in heat generation which modifies the cutaneous blood flow. This results in a sense of warmth on the ear and burning and tingling sensation on the face. The proximity of hand-held devices to oral structures especially salivary glands is known to cause changes in its function and properties.[12]

Studies have shown that there is increased nickel ion release in saliva following fixed orthodontic therapy which is further worsened by the usage of mobile phones due to its proximity to the oral cavity. As nickel is a well-known causative agent for hypersensitivity reactions and also a potential carcinogen, it is essential to maintain a lower level in saliva.

The effects of mobile phones in metal ion release are mainly by the emission of radiofrequency emission radiation (RFER) and to control the exposure of RFER to the patients, in our study we decided to check whether the radiation exposure can be controlled by using earphones. So our investigation was to compare the mobile phone usage effects on fixed orthodontic appliance with and without usage of earphones.[13] In this regard, we selected 60 individuals with Angles class I bimaxillary protrusion and assessed their salivary nickel ion levels during the initial phase of leveling and aligning. To minimize the diurnal variation, the salivary samples were collected between 9 am and 11 am for all participants.

We instructed the participants to use hand-held mobile phones for a minimum of 30 minutes per day for two weeks following the initial sample collection. The minimal duration of 30 minutes was decided based on the results of Arbabi-Kalati et al. where they found that speaking in the mobile phone for more than 20 minutes showed a decreased total antioxidant capacity of saliva and increased risk of inflammatory diseases or oral cancer.[14]

After the second round of sample collection, the participants were instructed to use only headphones for their mobile usage and the third salivary sample was collected after two weeks and nickel ion levels were estimated.

In our study, we found a significant increase in nickel ion levels in the second sample compared with the first sample. This shows that hand-held mobile phones cause increased nickel ion release in saliva. The significant reduction in the third sample compared with the second sample shows that headphone usage could comparatively limit the release of nickel ion from orthodontic appliance in saliva.

The result obtained in our study could be due to the following reason. The heat generated with the usage of hand-held mobile phone changes the properties of saliva such as pH and flow rate. These changes increase the corrosion rate of orthodontic appliances by reducing the ability of the metal alloys to repassivate. This could be the reason why we found significant reduction in nickel ion levels in saliva following earphone usage as the heat generation is relatively less compared with the hand-held mobile phones.

To know whether gender has any role in the nickel ion release in saliva of orthodontic patients, we categorized the male patients as group I and female patients as group II. We found no significant difference between the two groups (Table 2). Thus, the result of our study suggests that gender plays no significant role in nickel ion release in saliva. This is in contrast to the results obtained by Saghiri et al.[6] where they found increased nickel ion release in female participants compared to male participants.

The results of our study show that patients undergoing fixed orthodontic therapy should be encouraged to use headphone rather than hand-held mobile devices. Though the results of our study are more encouraging, further studies on large scale is required for more authentic results. The study can be further elaborated and justified regarding proximity of mobile phone and comparative study with the usage of Bluetooth-assisted and wired head phone usage and their radiation impact in nickel ion release in fixed orthodontic appliance.

Conclusion

From this study, we conclude that there is an increase in the nickel ion levels in saliva of patients undergoing fixed orthodontic treatment. This is further increased with the usage of hand-held mobile phones which could be reduced to a significant extent with the usage of headphones regularly by patients undergoing orthodontic treatment.

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