Original Article

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Dentistry Section

Effect of Electromagnetic Radiation on the Mechanical Properties of Orthodontic Elastics: A Preliminary In-vitro Study

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ABSTRACT

Introduction: The use of mobile phones has considerably increased, and the Electromagnetic Radiation (EMR) caused by these devices may influence intraoral appliances. Intraoral elastics are commonly employed in orthodontics and require periodic changing by the patient to be effective. Unfortunately, changes in mechanical properties are one of the biggest drawbacks of using elastics.

Aim: To evaluate the effects of Radiofrequency Electromagnetic Radiation (RF-EMR) on the mechanical properties of intraoral orthodontic elastics under in-vitro conditions.

Materials and Methods: This in-vitro study was conducted in the Department of Orthodontics at Saveetha Dental College, Chennai, Tamil Nadu, India, from February 2022 to June 2022. A total of 300 elastics with different diameters and force-exerting abilities were selected and divided into five categories (n=60). The five elastic groups were yellow, blue, green, red, and pink. These elastics were then exposed to EMR emitted from a cellular device for 1.5 hours per day over two days. The mechanical properties of the elastics were tested before and after exposure to EMR. Analysis of variance was used to determine if a significant difference existed between the groups, and Tukey's post-hoc test was used to determine significant differences in the mean (p-value <0.05). The analysis was performed using Statistical Package for the Social Sciences (SPSS) version 23.0 (SPSS Inc., Chicago, IL, USA).

Results: The results of the present study showed a statistically significant difference in rupture strength (p<0.001) and force decay (p<0.001) of the intraoral elastics before and after exposure to EMR. However, there was no change in the thickness and optical properties of all the elastics after exposure. The average remaining force of the intraoral elastics after exposure to EMR emitted from a cell phone device was 41.1% after force decay, and red elastics were the least colour stable, while green elastics were the most colour stable.

Conclusion: EMR emitted from mobile phones and other devices can influence the mechanical properties of intraoral elastics in terms of rupture strength, force decay, and colour stability.

Keywords: Appliance, Force decay, Orthodontics, Phone, Rupture strength

INTRODUCTION

One of the most important goals of orthodontic treatment is to use light continuous force to achieve maximum effective tooth movement with minimal side effects [1]. For this purpose, various auxiliaries are used to move teeth, including coil springs, elastics, and elastomers [2]. Intraoral elastics have been one of the most versatile auxiliaries in orthodontics, and their use, combined with good patient cooperation, provides clinicians with the ability to correct both anteroposterior and vertical discrepancies [3].

Synthetic rubber polymers, such as polyurethane rubber, are commonly used for orthodontic purposes due to an increased incidence of latex allergic reactions, which led to the use of non-latex products within the orthodontic specialty [2]. Intraoral elastics can be classified in many ways based on the material, availability, uses, and force. Different manufacturers produce elastics with varying sizes, forces, colour coding, and names.

It is known that factors such as tooth movement, temperature changes, pH variations, oral fluoride rinses, salivary enzymes, and masticatory forces can all contribute to elastomer deformation, force degradation, and relaxation behaviour [4].

Smartphones became widely available to people starting from 2011, and since then, their usage has accelerated. The ownership of smartphones and electrical devices is now widespread, even among children aged 11 and older [5]. As a result, Electromagnetic Radiation (EMR) has started to pollute modern society [6]. Mobile phones, microwave ovens, communication base stations, high-voltage lines, electronic devices, and other electromagnetic equipment are just a few examples of electrical systems that are sources of EMR. These systems generate a range of electromagnetic waves with varied frequencies, causing an increase in EMR intensity in inhabited environments [7]. High-frequency waves, such as cosmic, gamma, and X-ray rays, have enough energy to ionize matter. On the other hand, non-ionising electromagnetic waves, including ultraviolet, visible-region, infrared, microwave, and radio waves, are frequently used in daily life, especially radiofrequency electromagnetic radiation (RF-EMR, 30 kHz-300 GHz) for communication, and extremely low-frequency electromagnetic radiation (ELF-EMR, 3 Hz-3 kHz) produced by electricity [7-9].

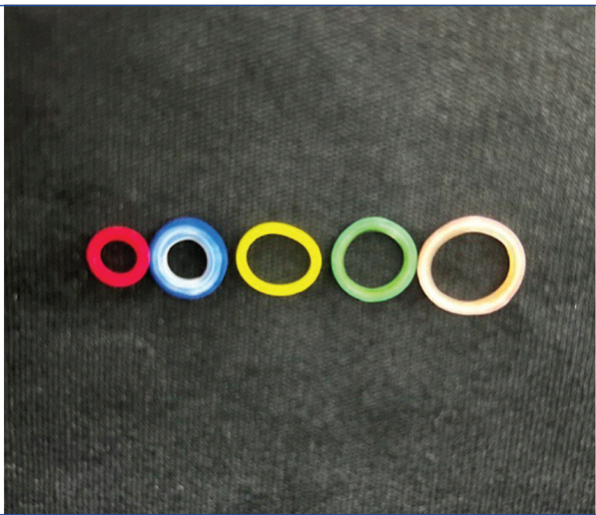
The effects of RF-EMR on the human body have been studied [10]. These radiations also affect intraoral appliances, such as orthodontic appliances. The use of mobile phones and other devices utilising Wi-Fi routers has significantly increased. Therefore, it is necessary to assess the interaction of this radiation with orthodontic appliances [10]. A study by Mortazavi SM et al., found that exposure to RF-EMR can lead to the release of nickel ions from metal orthodontic appliances [11].

Intraoral elastics are a crucial component of orthodontic treatment, and any change in their properties can affect the duration and outcome of the treatment. However, there are limited studies that have assessed the effects of EMR on the properties of orthodontic appliances [11,12]. The present study is the first of its kind to evaluate the effects of RF-EMR on the mechanical properties of intraoral orthodontic elastics under in-vitro conditions. The objective of this study was to assess the effect of RF-EMR on the mechanical properties of intraoral orthodontic elastics.

MATERIALS AND METHODS

This in-vitro study was conducted at the Department of Orthodontics, Saveetha Dental College, Chennai, India, over a period of five months, from February 2022 to June 2022. Institutional ethical clearance (SRB/SDC/ORTHO-2107/22/024) was obtained prior to the commencement of the study.

A total of 300 intraoral elastic samples were utilised for this study. The sample size was calculated using G* Power software (version 3.1) based on a previous study by Saghiri MA et al., [12]. With a study power of 95%, a probability of error of 0.05, and an effect size of 0.66, a minimum sample size of 27 per group was determined. Therefore, 60 samples per group were used in this study. The intraoral elastics were colour-coded based on thickness and applied force, and were categorised into five groups: Red (3/16" diameter), Blue (¼"), Green (5/16"), Yellow (5/16"), and Pink (3/8") [Table/Fig-1].



[Table/Fig-1]: Five groups of elastics used in the study: Group-1: Red (3/16" diameter); Group-2: Blue (¼"); Group-3: Green (5/16"); Group-4: Yellow (5/16"); and Group-5: Pink (3/8").

Inclusion criteria: The Orthodontic intraoral elastics with adequate shelf life and proper storage according to the manufacturer's instructions were included in the study.

Exclusion criteria: Extraoral elastics or elastics with breakages and deformities and the expired elastics were excluded from the study.

Procedure

The obtained elastic samples were within their designated shelf life and were stored in plastic covers provided by the manufacturer. They were kept away from direct sunlight to prevent heat distortion. All the elastics used in the study were manufactured by a single company, D Tech Orthodontics Pvt., Ltd., located in Pune, Maharashtra.

Under laboratory conditions, all the samples were tested for their mechanical properties, including thickness, rupture strength, force decay, and colour stability. These mechanical properties were evaluated for all the groups both before and after exposure to RF-EMR.

Parameters studied:

1. **Rupture strength:** The rupture strength of each elastic was tested using the Instron universal testing machine (Boston, Massachusetts). The machine was set to a speed of 1 mm per minute with a load of 500 N [Table/Fig-2]. The elastic was stretched at the specified rate until it ruptured, and the value at which the rupture occurred was recorded for all the groups.
2. **Thickness:** The thickness of the samples was measured to the second decimal point using vernier calipers (Freemans 0-150 stainless steel caliper, FMI Limited, Gurugram, India). Initial measurements were performed by one operator, and the values were repeated by a second operator. The average value was recorded for each sample.
3. **Force decay:** Force decay was measured using an electronic force gauge (Shimpo DFS-1; Nidec-Shimpo America Corp., Itasca, USA) attached to a test stand with a flexible platform. The intraoral elastics were attached to the electronic force gauge and stabilised for 5 seconds before recording the force levels. The technique for measuring force decay was based on a study by Aldrees AM et al., [13]. The measured forces were recorded in an Excel spreadsheet (Microsoft Corp., Redmond, WA, USA). The force decay percentage was calculated using the following formula: Force Decay (%)={(Initial Force-Subsequent Force)/Initial Force}×100. The calculated force decay percentage represents the relative change in the force exerted by the elastics between the preoperative and postoperative measurements. A higher force decay percentage indicates a greater reduction in force, suggesting potential instability or changes in the elastics.

[Table/Fig-2]: The rupture strength of the elastics being tested in the Instron Universal testing machine.

4. **Optical properties:** The optical properties of the elastics were tested using a colorimeter (Oakton, Germany). All the samples were placed in a bundle in a Petridish above the measuring tip. The colour parameter was based on the Commission Internationale de l'Eclairage (CIE) L*a*b* colour space system. In this system, L* represents lightness, a* represents the red-green hue, and b* represents the yellow-blue hue in a three-dimensional colour system. The L* axis represents brightness, with higher values indicating increased brightness. The a* value denotes the degree of redness (+a*) or greenness (-a*), and the b* value denotes the degree of yellowness (+b*) or blueness (-b*) of an object. Values for L*, a*, and b* were obtained from the colorimeter. The optical property measurements were based on a study conducted by Aldrees AM et al., [13].

Exposure to RF-EMR: To determine the duration of exposure to radiation, a mobile survey was conducted among 180 orthodontic patients above the age of 11 years at the hospital. The sample was collected conveniently from patients who visited the orthodontic department within a week. The duration of phone usage was estimated from the mobile settings, which provided an average duration of phone usage including calls and other apps. The average duration was recorded and tabulated.

The survey revealed that out of the 180 patients, 60 (33.33%) used their mobile phones for an average time of 47-60 minutes, 100 patients (55.55%) used their mobile phones for an average time of 90-100 minutes, and 20 patients (11%) used their mobile phones for 120 minutes. To determine the overall average mobile phone usage time, an average value was calculated, which equated to 90 minutes (1.5 hours) per day. This average duration was considered as the standard for exposing the elastics to RF-EMR.

The elastic samples were placed in a cardboard box along with a fully functional mobile phone, and the box was sealed. A Trifield TF2 EMF (Electromagnetic Frequency) detector was attached to the same box to ensure the proper functioning of the mobile phone. The Trifield TF2 EMF detector was used to measure the strength of RF-EMR during the experiment, ensuring that the elastics were adequately exposed to the radiation for 1.5 hours. Once the apparatus was prepared, a call was initiated on the mobile phone placed inside the box. Throughout the study, the Trifield TF2 EMF detector displayed a value of 2.1-2.4 GHz, which was maintained.

The ongoing call was set to a duration of 1.5 hours for one day. After completing the desired exposure time, the elastics were taken to the laboratory for the same tests conducted prior to EMR exposure. The obtained values for all the tests were recorded and tabulated.

STATISTICAL ANALYSIS

All data was collected and tabulated using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) for subsequent statistical analysis. Descriptive statistics were performed using SPSS software version 23.0. Inter group comparisons were conducted using one-way ANOVA with Tukey's post-hoc test to compare rupture strength and force decay. The significance level (p-value) was set at 0.05 with a 95% level of significance. Additionally, paired sample t-tests were conducted to compare pre and post-exposure thickness and colour stability.

RESULTS

In the present study, mean values of rupture strength, both before and after radiation exposure, were recorded and tabulated in MPa [Table/Fig-3]. The post-exposure rupture strength for all the elastics was lower than the pre-exposure data. A one-way ANOVA test was performed to calculate the overall means and level of significance for the pre-exposure and post-exposure groups, which showed a statistically significant difference ($p<0.001$) [Table/Fig-4].

Elastics	Pre-exposure rupture strength (Mpa)	Post-exposure rupture strength (Mpa)
Blue	100.74	47.69
Red	33.48	30.29
Green	31.57	40.00
Yellow	50.33	38.01
Pink	40.93	29.31

[Table/Fig-3]: Pre-exposure and post-exposure rupture strength values (Mpa) of the five different types of intraoral elastics.

		Mean	Significance
Post-exposure rupture strength	Between groups	378.6	**<0.001**
	Within groups	1.4	**<0.001**
Pre-exposure rupture strength	Between groups	564.6	**<0.001**
	Within groups	0.082	**<0.001**

[Table/Fig-4]: Level of significance between post-exposure and pre-exposure rupture strength.
One-way ANOVA was applied for statistical analysis

The study revealed that the blue and red elastics had a statistically significant change ($p<0.001$) in rupture strength compared to all other groups. The blue elastic showed the highest reduction in rupture strength. All the groups, except for the green elastic, showed a decrease in mean rupture strength after radiation exposure. The green elastic showed a slight increase in rupture strength after radiation exposure compared to the pre-exposure [Table/Fig-3]. The intergroup comparison was conducted using the Post-hoc Tukey test [Table/Fig-5,6].

	Elastic	As compared to	Mean difference	Significance
Post-exposure rupture strength	Blue	Red	17.3	**<0.001**
		Green	7.7	**<0.001**
		Yellow	8.8	**<0.001**
		Pink	7.6	**<0.001**
	Red	Blue	-17.3	**<0.001**
		Green	-9.5	**<0.001**
		Yellow	-8.5	**<0.001**
		Pink	-9.6	**<0.001**
	Green	Blue	-7.7	**<0.001**
		Red	9.5	**<0.001**
		Yellow	1.0	0.31
		Pink	-0.08	0.20
	Yellow	Blue	-8.8	**<0.001**
		Red	8.5	**<0.001**
		Green	-1.0	0.314
		Pink	-1.1	0.238
	Pink	Blue	0.00	**<0.001**
		Red	0.00	**<0.001**
		Green	1.0	1.00
		Yellow	1.1	0.2

[Table/Fig-5]: The Tukey's post-hoc test was applied for inter-group comparison of the post-exposure rupture strength.

	Elastic	As compared to	Mean difference	Significance
Pre-exposure rupture strength	Blue	Red	17.2	**<0.001**
		Green	9.0	**<0.001**
		Yellow	7.4	**<0.001**
		Pink	18.2	**<0.001**
	Red	Blue	-17.2	**<0.001**
		Green	-8.1	**<0.001**
		Yellow	-9.7	**<0.001**
		Pink	1	**<0.001**
	Green	Blue	-9.0	**<0.001**
		Red	8.1	**<0.001**
		Yellow	-1.5	**<0.001**
		Pink	9.1	**<0.001**
	Yellow	Blue	-7.4	**<0.001**
		Red	9.7	**<0.001**
		Green	1.5	**<0.001**
		Pink	10.7	**<0.001**
	Pink	Blue	-18.2	**<0.001**
		Red	-1.0	**<0.001**
		Green	-9.1	**<0.001**
		Yellow	-10.7	**<0.001**

[Table/Fig-6]: The Tukey's post-hoc test was applied for inter-group comparison of the pre-exposure rupture strength.

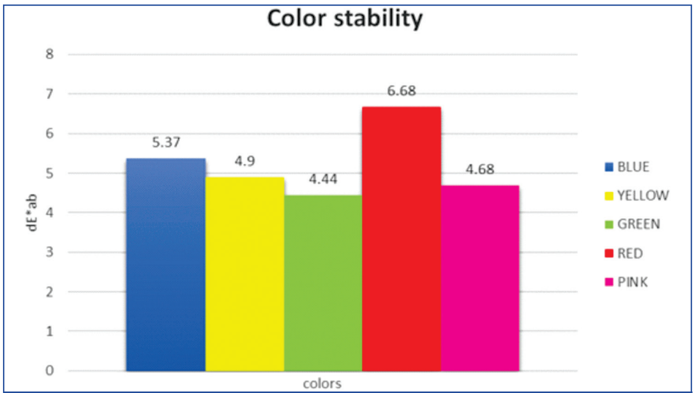
Thickness: A comparison of the thickness of the elastics before and after exposure to cell phone radiation was performed. The mean thickness pre-exposure was 14.75±6.6 mm, and the mean thickness post-exposure was 6.86±6.7 mm. The mean change in thickness was 7.89±8.9 mm. However, there was a statistically insignificant reduction in the mean thickness values ($p=0.791$).

Force decay: The mean force decay between the pre and post-exposure is shown in [Table/Fig-7]. The table demonstrates an increase in force decay after exposure to radiation. There was a statistically significant decrease ($p<0.01$) in the force levels post-exposure. The overall force loss for the elastics after exposure to RF-EMR was 41.1%.

Elastic	Post-exposure	Pre-exposure	p-value
Blue	224.49±10.09	220.03±11.92	**<0.001**
Red	191.70±13.33	165.72±10.19	**<0.001**
Green	186.16±10.25	162.43±13.68	**<0.001**
Yellow	179.13±10.41	146.43±13.27	**<0.001**
Pink	179.75±16.45	138.56±14.11	**<0.001**

[Table/Fig-7]: Mean, standard deviation and p-values of the force decay pre and post exposure to Electromagnetic Radiation (EMR).

Colour stability: The optical properties of the elastics before and after exposure to cell phone radiation were compared in this study. The bar graph displays the mean difference between the pre- and post-recorded optical properties, calculated using the formula $\Delta E^*ab=((\Delta L^*)2+(\Delta a^*)2+(\Delta b^*)2)1/2$ [Table/Fig-8]. The green elastic showed the least colour change, while the red elastic showed the highest colour change. A paired t-test was conducted to compare the means. However, the colour change was not statistically significant.



[Table/Fig-8]: Bar graph representing the colour stability of the different colours of intraoral elastics.

DISCUSSION

Mobile phones and digital communication systems have become integral parts of life, giving rise to concerns about the potential adverse health effects of RF-EMR on human health [11]. Insufficient understanding of these effects has raised concerns among healthcare professionals and researchers. Given the proximity of mobile phones to the oral cavity during conversations and the presence of orthodontic appliances in the mouth, there may be an increased risk of exposure of these appliances to mobile phone radiation [12]. The aim of the present study was to determine the potential effects of RF-EMR on intraoral elastics commonly used in orthodontic treatment. Five groups of elastics with different internal diameters, coded by different colours, were used in the study. All the elastics were obtained from a single manufacturer, as the properties of elastics can vary between different manufacturers. Mechanical properties such as rupture strength, force decay, thickness, and colour stability were tested for all the samples before and after exposure to RF-EMR. A Trifield EMF detector, as used in the study by Siddiqi N et al., [14], was used in the present study to detect the strength of EMRs and ensure that the mobile phones transmitted RF-EMR throughout the duration of the study.

The main outcome of this preliminary study is that, under in-vitro conditions, RF-EMR emitted from a mobile phone has an effect on the mechanical properties of orthodontic intraoral elastics. The study found statistically significant changes in the rupture strength of blue and red elastics compared to all other groups after exposure to radiation. Various other factors such as salivary pH, use of dentifrices, and beverages can also affect the rupture strength of orthodontic elastics [15]. A study by Braga E et al., found significant changes in rupture strength after immersion in various beverages [15]. Another study by Berni Osorio L et al., investigated the effect of different disinfection solutions on the rupture strength of elastomeric ligatures and chains, finding a statistically significant difference when disinfected with 70% alcohol [16]. The force exerted by orthodontic elastics depends on their diameter, thickness, and the distance between points of force application [17]. The thickness of elastics can vary among different manufacturers [18]. In the present study, elastics manufactured by a single company were used to minimise variations. The study showed no statistically significant change in the thickness of the elastics before and after radiation exposure.

The force decay in the post-exposure group was significantly higher. The average force decay of intraoral elastics after exposure to EMR emitted from a cell phone device was 41.1%. This force decay may be attributed to the degradation of elastic properties due to radiation exposure. Various factors such as lumen size of the elastics, saliva environment, pH, and thermocycling can influence the force decay of elastics [19]. Russell KA et al., reported faster rates of force loss for heavy elastics compared to medium elastics in certain brands, particularly in the first few hours [20]. In the present study, the red elastic, which is the heaviest in the group, experienced the highest force loss, which is consistent with previous studies [19,21,22].

The colour stability of the elastics was assessed using ΔE, which represents the magnitude of total colour difference between pre and post-exposure, calculated as $\Delta E=\{(DL^*)^2+(Da^*)^2+(Db^*)^2\}^{(1/2)}$. The CIE L*a*b* colour space consists of three coordinates: L* (lightness), a* (green-red), and b* (blue-yellow) [13]. The present study found no statistically significant differences between the pre and post-exposure groups in terms of colour stability. Ravisankar A and Arun AV investigated the effect of cellular radiation on the elasticity of elastomeric chains and found statistically significant changes, similar to the intraoral elastics, which are also affected by RF-EMR [23].

Previous studies have examined the effects of RF-EMR on orthodontic brackets and wires. The impact of RF-EMR on metal brackets leading to nickel ion leaching has been documented, highlighting the harmful effects of mobile phone radiation [12,24]. Saghiri MA et al., discovered that RF-EMR can indirectly cause DNA damage by influencing the release of nickel from fixed orthodontic appliances [12]. Nanjannawar LG et al., concluded that mobile phone radiation can influence the pH and nickel ion release in the saliva of patients undergoing fixed orthodontic treatment [24]. They found that longer exposure to RF-EMR emitted by a mobile phone resulted in higher concentrations of nickel in saliva. Ionescu IC and Ionescu E found that RF microwave effects and electromagnetic fields can potentially impact orthodontic treatment by altering saliva pH [25].

The use of mobile phones has significantly increased among individuals, and this change in lifestyle can impact the properties of orthodontic appliances. Further studies are needed to understand the mechanism by which radiation can cause changes in the mechanical properties. Clinically, these deteriorating mechanical properties can lead to a reduction in the force applied by the elastics on the teeth [25]. Currently, intraoral elastics are typically changed every two days, but based on the results of this study, it may be advisable to change them daily due to the increased force decay caused by cellular radiation.

The blue and red elastics are commonly used for antero-posterior corrections and occlusion settling, making them routinely used in orthodontic treatment. Based on the results of this study, there is a statistically significant difference in the rupture strength and force decay of these elastics before and after exposure to radiation. This can affect the force-rendering capacity of these elastics and also impact inventory needs. It is important for practitioners to have a good understanding of elastic properties and the factors that can alter them [26]. Further research is needed to investigate the potential effects of RF-EMR on various orthodontic materials used in the patient's mouth. Additionally, more in-depth research at the molecular level is necessary to understand how radiation can alter the properties of these materials.

Limitation(s)

The main limitation of the study is that the materials were tested in-vitro, and the results may be influenced by variations in intraoral conditions in clinical settings. Therefore, generalisability of the findings can only be established through in-vivo studies. Additionally, the radiation emitted by mobile phones can vary depending on factors such as the model, communication system, and type of use. The study only investigated the radiation emitted during phone calls, and did not assess the relationship between the duration of exposure to radiation and the mechanical properties of the elastics. This aspect is important and requires further investigation.

CONCLUSION(S)

Mobile phone radiation can influence the mechanical properties of intraoral elastics, specifically in terms of rupture strength and force decay. The force-rendering capacity of the elastics can be affected by RF-EMR due to its impact on the mechanical properties of the elastics.

REFERENCES

[1] Karad A. Clinical Orthodontics: Current Concepts, Goals and Mechanics. 1st Edition, New York, NA: Elsevier; 2010.
[2] Kamisetty SK, Nimagadda C, Begam MP, Nalamotu R, Srivastav T, Gs S. Elasticity in Elastics-An in-vitro study. J Int Oral Health. 2014;6(2):96-105.
[3] Mansour AY. A comparison of orthodontic elastic forces: Focus on reduced inventory. J Orthod Sci. 2017;6(4):136-40.
[4] Singh V, Pokharel P, Pariekh K, Roy D, Singla A, Biswas K. Elastics in orthodontics: A review. Health Renaissance. 2012;10(1):49-56.
[5] Sohn SY, Rees P, Wildridge B, Kalk NJ, Carter B. Prevalence of problematic smartphone usage and associated mental health outcomes amongst children and young people: A systematic review, meta-analysis and GRADE of the evidence. BMC Psychiatry. 2019;19:356. https://doi.org/10.1186/s12888-019-2350-x.
[6] Hu C, Zuo H, Li Y. Effects of radiofrequency electromagnetic radiation on neurotransmitters in the brain. Front Public Health. 2021;9:691880. https://doi.org/10.3389/fpubh.2021.691880.
[7] Wei Y, Yang J, Chen Z, Wu T, Lv B. Modulation of resting-state brain functional connectivity by exposure to acute fourth-generation long-term evolution electromagnetic field: An fMRI study. Bioelectromagnetics. 2019;40(1):42-51. Doi: 10.1002/bem.22165 2.
[8] Yang L, Zhang C, Chen Z, Li C, Wu T. Functional and network analyses of human exposure to long-term evolution signal. Environ Sci Pollut Res Int. 2021;28(5):5755-73. Doi: 10.1007/s11356-020-10728-w 3.
[9] Megha K, Deshmukh PS, Banerjee BD, Tripathi AK, Ahmed R, Abegaonkar MP. Low intensity microwave radiation induced oxidative stress, inflammatory response and DNA damage in rat brain. Neurotoxicology. 2015;51:158-65. Doi: 10.1016/j.neuro.2015.10.009.
[10] Singh K, Nagaraj A, Yousuf A, Ganta S, Pareek S, Vishnani P. Effect of electromagnetic radiations from mobile phone base stations on general health and salivary function. J Int Soc Prev Community Dent. 2016;6(1):54-59.
[11] Mortazavi SM, Paknahad M, Khaleghi I, Eghlidospour M. Effect of radiofrequency electromagnetic fields (RF-EMFS) from mobile phones on nickel release from orthodontic brackets: An in vitro study. International orthodontics. 2018;16(2):562-70.
[12] Saghiri MA, Orangi J, Asatourian A, Mehriar P, Sheibani N. Effect of mobile phone use on metal ion release from fixed orthodontic appliances. Am J Orthod Dentofacial Orthop. 2015;147(6):719-24.
[13] Aldrees AM, Al-Foraidi SA, Murayshed MS, Almoammar KA. Color stability and force decay of clear orthodontic elastomeric chains: An in vitro study. Int Orthod. 2015;13(3):287-301.
[14] Siddiqi N, Heming T, Shalaby A, Al-Kindi M, Al-Ghafri F. Mobile phone electromagnetic waves causing fatty change in the hepatocytes of the developing chick embryo: Are smart phones too close for comfort? Biomed Pharmacol J. 2017;10(3). Doi : https://dx.doi.org/10.13005/bpj/1214.
[15] Braga E, Souza G, Barretto P, Ferraz C, Pithon M. Experimental evaluation of strength degradation of orthodontic chain elastics immersed in hot beverages. Journal of Indian Orthodontic Society. 2019;53(4):244-48.
[16] Berni Osorio L, Makito Osawa Gutierrez L, Martinelli de Lima E, Gonçalves Mota E, Macedo de Menezes L. Disinfection of orthodontic elastomers and its effects on tensile strength. Turk J Orthod. 2022;35(1):22-26.
[17] Seibt S, Salmoria I, Cericato GO, Paranhos LR, Rosario HD, El Haje O. Comparative analysis of force degradation of latex orthodontic elastics of 5/16" diameter: An in vitro study. Minerva Stomatol. 2016;65(5):284-90.
[18] Kersey ML, Glover K, Heo G, Raboud D, Major PW. An in vitro comparison of 4 brands of nonlatex orthodontic elastics. Am J Orthod Dentofacial Orthop. 2003;123(4):401-07.
[19] Qodcieh SM, Al-Khateeb SN, Jaradat ZW, Abu Alhaija ES. Force degradation of orthodontic latex elastics: An in-vivo study. Am J Orthod Dentofacial Orthop. 2017;151(3):507-12.
[20] Russell KA, Milne AD, Khanna RA, Lee JM. In vitro assessment of the mechanical properties of latex and non-latex orthodontic elastics. Am J Orthod Dentofacial Orthop. 2001;120(1):36-44.
[21] Wong A. Orthodontic elastic materials. Angle Orthod. 1976;(46):196-205.
[22] Taloumis L, Moles JA, Hopkins R. Instructions for wearing elastics. J Clin Orthod. 1995;29:49.
[23] Ravisankar A, Arun AV. Effect of cellphone radiation on permanent deformation of elastic chains. IJSER. 2017;5(8):01-06.
[24] Nanjannawar LG, Girme TS, Agrawal JM, Agrawal MS, Fulari SG, Shetti SS, et al. Effect of mobile phone usage on nickel ions release and pH of saliva in patients undergoing fixed orthodontic treatment. J Clin Diagn Res. 2017;11(9):ZC84-ZC87.
[25] Ionescu IC, Ionescu E. Orthodontic archwires and brackets may interact with mobile phones in close proximity. Proc Rom Acad Series B. 2012;(2):135-42.
[26] Beattie S, Monaghan P. An in vitro study simulating effects of daily diet and patient elastic band change compliance on orthodontic latex elastics. Angle Orthod. 2004;74(1):234-39.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Mar 23, 2023
- Manual Googling: May 18, 2023
- iThenticate Software: Sep 04, 2023 (12%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

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