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Original Article

Dentistry Section

Impact of Fluoride Mouthwash on Nickel Ion Release from Orthodontic Brackets: An In-vitro Study

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ABSTRACT

Introduction: In orthodontic patients, the orthodontic brackets and wires are exposed to the oral fluids for a considerable period of time. Patients use fluoridated mouthwashes to maintain oral hygiene and avoid white spot lesions on their teeth, which can cause release of nickel and chromium from the orthodontic brackets and thus may lead to allergic reactions and cytotoxicity.

Aim: To evaluate the amount of nickel ion release from orthodontic brackets on exposure to different fluoride mouthwashes.

Materials and Methods: This in-vitro experimental study was conducted on 75 orthodontic brackets, which were divided into three groups of 25 each and immersed in artificial saliva (group A), Amflor mouthwash (group B), and Zerosense (group C) mouthwash in separate beakers. The temperatures of the solutions in the beakers were maintained at 37° to simulate oral temperatures. The 5 mL of the solutions were drawn from the three breakers at 1, 6, 12, and 24 hours and the nickel ion release from each solution was measured using Optima 5300 Dual View (DV) Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES). One-way Analysis of Variance (ANOVA) with a post hoc test was performed for comparison between the groups and at different time intervals.

Results: The highest mean value of nickel release was noted in group C (0.32±0.020156 µg/mL) at the 24 hours peak time followed by group B (0.24±0.014338 µg/mL). Statistical analysis showed a significant difference between the two experimental groups at all time periods except 1 hour (p-value <0.05).

Conclusion: The amount of nickel ion release did not exceed the permissible limit in any of the study groups. However, it can be inferred that Amflor mouthwash can be preferred over Zerosense mouthwash for orthodontic patients considering the lower nickel ion release.

Keywords: Corrosion, Metal brackets, Nickel cytotoxicity

INTRODUCTION

Orthodontic brackets are mostly made from American Iron and Steel Institute type 316L austenitic Stainless Steel (SS). Such steel contains biomaterials of 18-20% chromium, 8-10% nickel with a small amount of manganese and silicon with the remainder being iron. They also have very low carbon content (less than 0.03%). Different manufacturers use different types of SS for better corrosion resistance and mechanical properties, including 304 SS, 316 SS, and 17-4 Precipitation-Hardening SS [1]. Nickel in SS stabilises the austenitic phase of SS and also enhances the alloy's anticorrosive properties [2]. However, nickel is a potent immunologic sensitizer and the leading cause of allergic contact dermatitis, a type IV delayed hypersensitivity immune response [3]. Nickel allergy causes burning sensation, rashes, swelling, and painful erythematous lesions in the mouth and labial mucosa. The allergic reactions also include gingivitis, gingival hyperplasia, lip desquamation, metallic taste, angular cheilitis, and periodontitis [4]. This is of concern to an orthodontist as nickel leeches from the brackets and the orthodontic wires into the saliva [5,6]. Nickel discharge from NiTi orthodontic wires in artificial saliva have been studied and it has been discovered that nickel release increases as the pH increases [4].

Fluoride mouthwashes are being advised for the maintaining good oral hygiene and prevention of White spot lesions by aiding remineralisation [7,8]. Fluoride's effective caries-prevention property is by producing hydrofluoric acid (HF), the fluoride ion of which acts as a bactericidal agent. However, HF output has been shown to damage orthodontic wires and brackets. HF corrodes the appliance's surface by destroying the protective oxide layer [9-12]. Previous research has been conducted to observe how fluoride mouthwashes influence nickel release from orthodontic brackets and wires [13-15]. Earlier studies have evaluated the effect of various mouthwashes on the ion release from orthodontic brackets [16,17]. However, there has been no study on the effect of Amflor fluoridated mouthwash on nickel ion release from orthodontic brackets. In this study, the authors assessed the effect of two different fluoride mouthwashes, namely Amflor and Zerosense on nickel ion release from orthodontic brackets and compared it with that of artificial saliva.

MATERIALS AND METHODS

This in-vitro experimental study was conducted in Saveetha Dental College and Hospital, Chennai in August, 2021. Ethical approval was obtained from the institutional review board (IHEC Ref NO: IHEC/SDC/ORTHO-2002/22/375). This study consisted of 75 orthodontic metal brackets (3M-Abzil kiriumR), which were divided into three groups of 25 brackets each:

- Group A-Artificial saliva,
- Group B-Amflor mouthwash,
- Group C-Zerosense mouthwash

Procedure

These brackets were immersed in 50 mL of their respective solutions that were kept in separate beakers for 24 hours. The fluoride mouthwashes used for the study namely Amflor and Zerosense mouthwashes were commercially purchased and were not diluted for the study. The artificial saliva used in Group A was prepared according to study by Levine MJ et al., [18].

The temperature of the solutions in the beakers were maintained at 37° to simulate oral temperatures. At intervals of 1, 6, 12, and 24 hours, 5 mL of the solutions were drawn from the three breakers and tested for nickel ion using Optima 5300 DV ICP – OES.

STATISTICAL ANALYSIS

The statistical software International Business Management Statistical Package for Social Sciences statistics version 23.0 was used for

statistical analysis. The data on the amount of nickel ions released from the orthodontic brackets in the different solutions at various time intervals were then distributed into google spreadsheet. The mean and standard deviation of each group were obtained. To check for significant differences between the three groups involved, a one-way ANOVA was performed with a post hoc test to find significance at difference time intervals between the groups. The level of significance was set at 95%.

RESULTS

The amount of nickel ion released was highest at 12 hour time period in both the Amflor and Zerosense mouthwash groups. The mean values of nickel ions released for each group at various time intervals are given in [Table/Fig-1]. One-way ANOVA was used for finding statistically significant differences between all the time intervals is shown in [Table/Fig-2]. Statistically significant nickel release was observed between the three groups in all the time intervals studied; hence a post hoc test was conducted to determine the statistical significance at various time intervals [Table/Fig-3].

Time interval (hours)	Group A (µg/mL)	Group B (µg/mL)	Group C (µg/mL)
1	0.031±0.009129	0.052±0.002754	0.064±0.002944
6	0.068±0.002754	0.083±0.002217	0.114±0.003304
12	0.074±0.003109	0.108±0.006994	0.122±0.002986
24	0.087±0.002217	0.24±0.014338	0.32±0.020156

[Table/Fig-1]: Represents Mean±SD values of each group at different time intervals.
Group A-artificial saliva, Group B-Amflor mouthwash, Group C-Zerosense mouthwash

Duration		Sum of squares	df	f	Significance (p-value)
1 hour	Between groups	0.001	2	12.073	**0.003**
	Within groups	0.000	9		
	Total	0.001	11		
6 hours	Between groups	0.004	2	268.057	**<0.001**
	Within groups	0.000	9		
	Total	0.004	11		
12 hours	Between groups	0.004	2	93.670	**<0.001**
	Within groups	0.000	9		
	Total	0.004	11		
24 hours	Between groups	0.136	2	331.381	**<0.001**
	Within groups	0.002	9		
	Total	0.138	11		

[Table/Fig-2]: Represents comparison of three groups at different time intervals using One Way ANOVA.
All bold p-values are significant; Group A-Artificial saliva, Group B-Amflor mouthwash, Group C-Zerosense mouthwash

Groups	1 hour	6 hour	12 hour	24 hour
Group A vs Group B	0.063	**0.002**	**<0.001***	**<0.001***
Group A vs Group C	**0.002**	**<0.001***	**<0.001***	**<0.001***
Group B vs Group C	0.112	**<0.001***	**<0.001***	**<0.001***

[Table/Fig-3]: Shows a comparison of three groups at various time intervals using the post hoc test.
All bold p-values are significant; Group A-Artificial saliva, Group B-Amflor mouthwash, Group C-Zerosense mouthwash

When Group B (0.052±0.002754) was compared with Group A (0.031±0.009129) and Group C (0.064±0.002944) at 1 hour intervals, there was no significant difference (p>0.05); however, when group A (0.031±0.009129) was compared with group C (0.064±0.002944) at the same hour, there was a significant difference in the amount of ions released (p=0.002). There was a substantial difference in ion release across the groups at 6-, 12-, and 24-hour time intervals. Based on the mean values, this study concluded that Zerosense mouthwash had a higher amount of ion release than the other two at all time intervals which was significant at all time intervals from 6 to 24 hours (p<0.05).

DISCUSSION

The study aimed to evaluate the amount of nickel ion release from the orthodontic brackets when immersed in fluoride mouthwashes at different time intervals. When the three groups were compared, Amflor mouthwash showed no significant difference when compared to artificial saliva and Zerosense mouthwash; however, when artificial saliva was compared with Zerosense mouthwash, there was a significant difference in the amount of ion released at 1 hour interval. However, there was a substantial difference in ion release across the groups from 6-hour time intervals with Zerosense causing the maximum release.

Nickel ions are often the major concern among various ions released by stainless steel due to its ability to cause allergic, toxic, or carcinogenic reactions [19-21]. The recommended maximum limit of nickel ion release that would not cause any negative reactions is 200-300 µg/day by World Health Organisation [22]. Clinicians should be aware that the release of metal ions can result in local hypersensitivity reactions, such as mild erythema or redness with or without oedema, at oral soft-tissue sites. Acute gingivitis can also appear as a hypersensitivity reaction when associated with poor oral hygiene [23-25]. These symptoms can be severe for a short time or mild for a longer time, and some can be treated, while others can become a persistent problem [26].

Patients are recommended to use mouthwash twice a day for approximately 2 min. It is advised that the patient does not eat, drink, or rinse after mouth washing, since the components of mouthwash remain in the mouth for a long time. It is difficult to establish the exact period of contact between brackets and mouthwashes as it depends on a lot of factors like oral temperature, pH of saliva, which differs when reacting with food substances, concentration of mouthwash solution and other beverages [23,27,28]. The study also evaluated for how much nickel ion is released from SS brackets during the treatment period and whether it reaches the toxicity level during the treatment period. On an average, if a patient uses mouthwash once a day for approximately 2 min, it works out to 60 mins (2 mins×30 days) for a month. With an approximate orthodontic treatment period of 24 months, the total time that the brackets and wires would be exposed to the mouthwash would be 1,440 mins (60 mins×24 month=1,440) or 24 hours. Hence, the exposure of the brackets to the mouthwashes/artificial saliva was 24 hours in the study [29].

The release of metals into the oral cavity by saliva can be affected by a high chloride content in saliva or due to consumption of low-pH foods [28,30]. Hence, artificial saliva was used to mimic an optimum oral environment. The fluidity of saliva in the mouth and the removal of oxide layers by tooth brushing will further cause metal release that could occur in real life [28]. The present study tested the mouthwashes in a static setting so as to obtain the ion release effect of mouthwashes/artificial saliva without being influenced by tooth brushing or any other means.

The amount of nickel released in artificial saliva during 24 hours in the present study sample were lower than Jamilian A et al., and Shruthi DP et al., [13,31]. Variations in ion release between brackets of different manufacturers and different solutions have been reported by Grimsdottir MR et al., [32]. In this study, when comparing Amflor and Zerosense mouthwashes to artificial saliva, the findings showed that at 1 hour, the difference in ion release was not significant. However, based on the values obtained, it can be inferred that Amflor mouthwash resulted in lesser ion release when compared to Zerosense mouthwash. The artificial saliva had the least nickel ion release as expected thus confirming that fluoride mouthwashes stimulate increased nickel ion release from orthodontic brackets and wires.

Similar research evaluating nickel ion release in orthodontic brackets/orthodontic wires in mouthwash solutions has been table/figured [Table/Fig-4] [16,29,33]. Two studies [29,16], compared

S. No.	Author's name and year of study	Place of study	Number of subjects	Mouthwashes compared	Parameter assessed	Conclusion
1.	Danaei SM et al., [29]	Iran	160 brackets	1. Oral-B (n=40) 2. Chlorhexidine (n=40) 3. Persica (n=40) 4. Deionized water (n=40)	Chromium Copper Iron Manganese Nickel	Recommended to avoid prolonged application of chlorhexidine in patients who have allergies.
2.	Deity T et al., 2018 [16]	Indonesia	36 brackets	1. Artificial saliva (n=12) 2. Chlorhexidine (n=12) 3. Piper betle Linn (n=12)	Corrosion on brackets Nickel ion release	Chlorhexidine has the highest nickel ion release from stainless steel brackets, followed by Piper betle Linn mouthwash.
3.	Mirhashemi A et al., 2018 [33]	Iran	120 orthodontic appliance (60 NiTi+60 SS)	1. Oral-B (n=24) 2. Oral-B White Luxe (n=24) 3. Listerine (n=24) 4. Listerine Advanced White (n=24) 5. Distilled water (n=24)	Nickel ion Chromium ion	Listerine causes the highest release of ions, and Listerine Advance White, Oral B 3D White Luxe, and distilled water were similar in terms of ion release. Oral B caused the lowest release of ions.
4.	Present study	India	75 orthodontic brackets	Artificial saliva (n=25) Amflor Fluoride (n=25) Zerosense (n=25)	Nickel ion release	Zerosense mouthwash was found to cause the highest amount of nickel ion release followed by Amflor mouthwash and artificial saliva.

[Table/Fig-4]: Comparative assessment of studies assessing the nickel ions release with the orthodontic appliances [16,29,33].

three mouthwashes over a 45-day period and found that the nickel ion release was higher in the chlorhexidine group compared to the Persica mouthwash, Oral-B mouthwash, Piper beetle Linn mouthwash, and deionized water group. The present study was conducted over 24 hours and hence cannot be directly compared. However, if the data has been multiplied from 24 hours values to 45 days, the authors obtained 1.44 µg/mL and 1.08 µg/mL for Zerosense and Amflor mouthwashes, respectively. These values were similar to the values for chlorhexidine 1.19 µg/mL. Mirhashemi A et al., [33] observed the nickel ion release in orthodontic wires and found that the quantity of ion release with listerine mouthwash was greater during a 24-hour time interval when compared to all other mouthwashes (Oral-B, Oral-B White Luxe, and Listerine Advanced White). Though the fluoride mouthwashes used in the study had nickel ion values comparable with that of chlorhexidine used in other studies, fluoride mouthwashes have a therapeutic effect of prevention and remineralisation of white spot lesions that occur with orthodontic treatment [34]. Hence fluoride mouthwashes are preferable in orthodontic patients. Among the two mouthwashes, Amflor mouthwash can be preferred as it had lesser nickel release when compared to Zerosense mouthwash.

Limitation(s)

Firstly, the bracket bases would be coated with adhesives in an actual clinical setting hence, the exposed surface for ion release in this study would be more than that of clinical conditions. The arch wire and brackets should ideally be subjected to a brushing stimulator so as to enable oxide layer removal when reacting to artificial saliva and fluoride mouthwash so as to mimic the actual oral environment. Secondly, the effect of oral temperature, pH of saliva, which differs when reacting with food substances, concentration of mouthwash solution and its reacting time with brackets, could be major factors that could increase the ion release from brackets and arch wires. All the above factors possibly having a greater influence on ion release from brackets and wires and giving varying results were not considered in this study.

CONCLUSION(S)

Zerosense mouthwash was found to cause greater nickel ion release followed by Amflor mouthwash and artificial saliva. The toxicity level of ions emitted in a given period of time in this study did not exceed the permissible limits (200-300 µg/day). However, as per the mouthwash use is concerned, it can be inferred that Amflor mouthwash can be prefered over Zerosense mouthwash for orthodontic patients considering the lower nickel ion release. Further studies with different mouthwashes and research settings should be conducted to accurately determine the ion release from orthodontic appliances and its effects on the oral cavity.

REFERENCES

[1] Sifakakis I, Eliades T. Adverse reactions to orthodontic materials. Aust Dent J. 2017;62:20-28.
[2] Anusavice KJ, Shen C, Rawls HR, editors. Phillips' science of dental materials. Elsevier Health Sciences; 2012. https://www.academia.edu/41764796/Phillips_Science_of_Dental_Materials_Phillip_Anusavice.
[3] Rahilly G, Price N. Nickel allergy and orthodontics. J Orthod. 2003;30(2):171-74.
[4] Senkutvan RS, Jacob S, Charles A, Vadgaonkar V, Jatol-Tekade S, Gangurde P. Evaluation of nickel ion release from various orthodontic arch wires: An in vitro study. J Int Soc Prev Community Dent. 2014;4(1):12-16.
[5] Ağaoğlu G, Arun T, İzgü B, Yarat A. Nickel and chromium levels in the saliva and serum of patients with fixed orthodontic appliances. Angle Orthod. 2001;71(5):375-79.
[6] Bishara SE, Ortho D, Jakobsen JR, Treder J, Nowak A. Arch width changes from 6 weeks to 45 years of age. Am J Orthod Dentofacial Orthop. 1997;111(4):401-09.
[7] Khoroushi M, Kachuie M. Prevention and treatment of white spot lesions in orthodontic patients. Contemp Clin Dent. 2017;8(1):11-19.
[8] Tahmasbi S, Adhami M, Valian A, Hamedi R. Effect of three different remineralizing agents on white spot lesions; An in vitro comparative study. J Iran Dent Assoc. 2016;28(3):98-103.
[9] Kwon YH, Cho HS, Noh DJ, Kim HI, Kim KH. Evaluation of the effect of fluoride-containing acetic acid on Nitti wires. Journal of Biomedical Materials Research Part B: Applied Biomaterials: An Official Journal of The Society for Biomaterials, The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials. 2005;72(1):102-08.
[10] Huang HH. Variation in surface topography of different NiTi orthodontic arch wires in various commercial fluoride-containing environments. Dent Mater. 2007;23(1):24-33.
[11] Kao CT, Ding SJ, Wang CK, He H, Chou MY, Huang TH. Comparison of frictional resistance after immersion of metal brackets and orthodontic wires in a fluoride-containing prophylactic agent. Am J Orthod Dentofacial Orthop. 2006;130(5):568.e1-9.
[12] Walker MP, White RJ, Kula KS. Effect of fluoride prophylactic agents on the mechanical properties of nickel-titanium-based orthodontic wires. Am J Orthod Dentofacial Orthop. 2005;127(6):662-69.
[13] Jamilian A, Moghaddas O, Toopchi S, Perillo L. Comparison of nickel and chromium ions released from stainless steel and NiTi wires after immersion in Oral B®, Orthokin® and artificial saliva. J Contempt Dent Pract. 2014;15(4):403-06.
[14] Schiff N, Dalard F, Lissac M, Morgan L, Grosgogeat B. Corrosion resistance of three orthodontic brackets: A comparative study of three fluoride mouthwashes. Eur J Orthod. 2005;27(6):541-49.
[15] Schiff N, Boinet M, Morgon L, Lissac M, Dalard F, Grosgogeat B. Galvanic corrosion between orthodontic wires and brackets in fluoride mouthwashes. Eur J Orthod. 2006;28(3):298-04.
[16] Deity T, Nasution I, Yusuf M. Nickel ion release from stainless steel brackets in chlorhexidine and Piper betle Linn mouthwash. Dental Journal (Majalah Kedokteran Gigi). 2018;51(1):05-09.
[17] Wendl B, Wiltsche H, Lankmayr E, Winsauer H, Walter A, Muchitsch A, et al. Metal release profiles of orthodontic bands, brackets, and wires: An in vitro study. J Orofac Orthop. 2017;78(6):494-03.
[18] Levine MJ, Aguirre A, Hatton MN, Tabak LA. Artificial salivas: Present and future. J Dent Res. 1987;66(1_suppl):693-98.
[19] Mockers O, Deroze D, Camps J. Cytotoxicity of orthodontic bands, brackets and archwires in vitro. Dent Mater. 2002;18(4):311-17.
[20] Haddad AC, Tortamano A, Souza AL, Oliveira PV. An in vitro comparison of nickel and chromium release from brackets. Dent Mater. 2009;23(4):399-406.
[21] Hedberg YS, Odenville Wallinder I. Metal release from stainless steel in biological environments: A review. Biointerphases. 2016;11(1):018901.
[22] Nickel. (Environmental Health Criteria 108). 383 Seiten, 36 Tab. World Health Organization, Geneva 1991. Preis: 38,– Sw.fr.; 34,20 US $ (Entwicklungsländer 26,60 Sw.fr.). Food/Nahrung 1992;36:102-102. https://doi.org/10.1002/food.19920360124.

[23] Park HY, Shearer TR. In vitro release of nickel and chromium from simulated orthodontic appliances. Am J Orthod. 1983;84(2):156-59.
[24] Rickles NH. Allergy in surface lesions of the oral mucosa. Oral Surg Oral Med Oral Pathol. 1972;33(5):744-54.
[25] Schriver WR, Shereff RH, Domnitz JM, Swintak EF, Civjan S. Allergic response to stainless steel wire. Oral Surg Oral Med Oral Pathol. 1976;42(5):578-81.
[26] Sectors JC, Babaei-Mahani A, Di Silvio L, Mjör IA, Wilson NH. The safety of nickel containing dental alloys. Dental Materials. 2006;22(12):1163-68.
[27] Barrett RD, Bishara SE, Quinn JK. Biodegradation of orthodontic appliances. Part I. Biodegradation of nickel and chromium in vitro. Am J Orthod Dentofacial Orthop. 1993;103(1):08-14.
[28] Hwang CJ, Shin JS, Cha JY. Metal release from simulated fixed orthodontic appliances. Am J Orthod Dentofacial Orthop. 2001;120(4):383-91.
[29] Danaei SM, Safavi A, Roeinpeikar SM, Oshagh M, Iranpour S, Omidekhoda M. Ion release from orthodontic brackets in 3 mouthwashes: An in-vitro study. Am J Orthod Dentofacial Orthop. 2011;139(6):730-34.
[30] Joseph A. Corrosion of orthodontic devices. In Seminars in orthodontics. 1997 (Vol. 3, No. 3, pp. 198-205). WB Saunders.
[31] Shruthi DP, Patil GS, Prithviraj DR. Comparative evaluation of ion release in bonded and nonbonded stainless steel brackets with use of different mouthwashes: An In vitro study. Contemp Clin Dent. 2020;11(1):15-19.
[32] Grimsdottir MR, Gjerdet NR, Hensten-Pettersen A. Composition and in vitro corrosion of orthodontic appliances. Am J Orthod Dentofacial Orthop. 1992;101(6):525-32.
[33] Mirhashemi A, Jahangiri S, Kharrazifard M. Release of nickel and chromium ions from orthodontic wires following the use of teeth whitening mouthwashes. Prog Orthod. 2018;19(1):4
[34] Benson PE, Pender N, Higham SM. Quantifying enamel demineralization from teeth with orthodontic brackets-a comparison of two methods. Part 1: Repeatability and agreement. Eur J Orthod. 2003;25(2):149-58.

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