Comparison of Nickel and Chromium Ion Release Using Four Different Commercially Available Mouthwashes on Orthodontic Brackets and Wires: An *In vitro* Study

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ABSTRACT

Aim: Ions such as nickel and chromium which form the main component of most alloys used in orthodontics are released from orthodontic wires and appliances and can cause allergic reactions and cytotoxicity. The release of ions increases with the intake of fluids. Our study aimed to assess the release of nickel and chromium ions from nickel titanium orthodontic wires following the use of four common mouthwashes. **Materials and Methods:** The orthodontic appliances were immersed in Amflor Oral Rinse (Fluoridated), Listerine Cool Mint Mouthwash (Alcohol Based), Colgate PlaxMouthwash (nonalcoholic), and Herbal Mouthwash (natural extracts) for 24 h. The samples were collected at four-time intervals and optical emission spectroscopy served to quantify the amount of released ions. **Results:** The results showed an increase in the release of nickel and chromium ions in all mouthwashes. The release of nickel ions was the highest in Amflor and the lowest in herbal mouthwash. Chromium ion release was highest with Amflor mouthwash. **Conclusion:** Fluoridated mouth rinses causes increased release of ions while herbal mouthwashes causing least release. Care must be taken while prescribing mouthwashes to sensitized patients.

KEYWORDS: *Inductively coupled plasma-optical emission spectrometry, mouthwashes, orthodontic wire*

INTRODUCTION

Fixed orthodontic appliances consist of stainless steel (SS) and nickel-titanium (NiTi) alloys. Chromium, cobalt, nickel, and titanium forms the major bulk of the alloys used in orthodontics. All these metals are susceptible to corrosion in the oral fluids and to fluids taken from external sources such as aerated drinks and mouthwashes. Corrosion occurs due to chemical, mechanical, thermal, microbiological, and enzymatic responses leading to ion release. Corrosion is an electrochemical phenomenon and occurs in the presence of two alloys and one medium with the presence of electrolytes.[1] The alloy with lower resistance against corrosion acts as the anode and dissolves into the electrolyte, and ions are then released.

When such reactions take place in oral cavities, ions are released and discoloration of the adjacent soft tissues, allergic reactions, or pain results. The released ions can also cause toxic and biological secondary responses. Nickel causes allergic reactions.[2] Nickel is the most common metal to cause contact dermatitis in orthodontics. NiTi alloys may have nickel content in excess of 50%

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and can thus potentially release enough nickel in the oral environment to elicit manifestations of an allergic reaction.

Allergic reactions to chromium released from orthodontic components have also been reported apart from the allergic reactions,[3,4] release of ions may even cause cytotoxic effects, mutagenesis, and carcinogenesis.[5] Oral hygiene, esthetics, and periodontal problems have been constantly associated with orthodontic treatment.[6] In general, orthodontic patients are usually concerned a lot more than others for their oral hygiene and appearance. Furthermore, orthodontists prescribe mouthwashes to their patients with the concern of periodontal sequel secondary to orthodontic treatment and white spot lesions,[7] which occurs quite frequently in orthodontic patients.[8,9]

Numerous studies have evaluated the release of ions from orthodontic wires and brackets in contact with the saliva and mouthwashes.[10] A previous study stated that orthodontists must be careful when prescribing mouthwashes for orthodontic patients with orthodontic appliances. The release of ions increases with an increase in the pH. It has been reported that the amount of ions released from NiTi wires is higher than that released from SS wires.

Mouthwashes are regularly recommended for patients undergoing orthodontic treatment as a measure to improve oral hygiene, prevent decalcification, and prevent periodontal breakdown. Commercially available mouthwashes can be broadly classified into four groups based on the composition: (a) Fluoride based, (b) Herbal based, (c) Alcohol based, and (d) Nonalcohol based. The majority of the orthodontic appliances such as brackets and wires operate over a long period and are subject to oral fluids, fluids from external sources such as mouthwashes and various oral conditions, which make them susceptible to corrosion. Nickel and chromium found in orthodontic appliances are known to have deleterious effects such as allergy reactions and changes in cellular activity.

This study aimed to assess the release of nickel and chromium ions from orthodontic assembly consisting of brackets and NiTi wire following immersion in four different commercially available mouthwashes including Amflor Oral Rinse (Fluoridated), Listerine Cool Mint Mouthwash (Alcohol Based), Colgate Plax Mouthwash (Non-Alcoholic), and Herbal Fresh Mouthwash (Herbal and natural extracts).

Materials and Methods

The study was approved by the scientific research board of the university and ethical clearance was obtained. In this *in vitro* study, the release of nickel and chromium ions from a multifarious orthodontic assembly was evaluated. The orthodontic assembly was representative of essential primary components for one quadrant. It included: 0.016-inch NiTi wire, five brackets, and one molar tube [Figure 1].

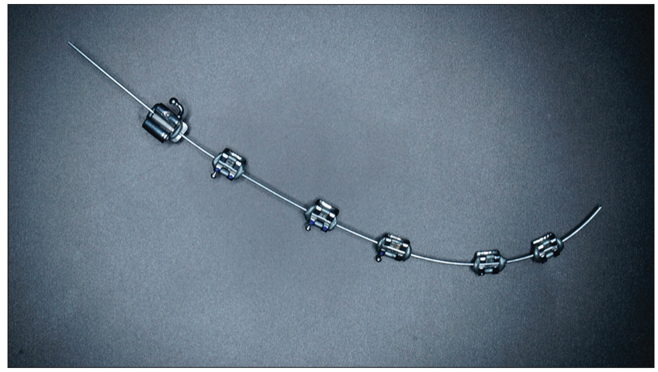

Figure 1: orthodontic assembly for one quadrant: Comprising 5 brackets, 1 buccal molar tube and 0.016" nickel titanium wire one quadrant

Four such assemblies were used in total for four different mouthwash groups. Four different mouthwashes used were: Group I - Amflor Oral Rinse (Fluoridated Mouthwash), Group II - Listerine Cool Mint Mouthwash (Alcohol-Based Mouthwash), Group III - Colgate Plax Mouthwash (Nonalcoholic Mouthwash), Group IV: Herbal Fresh Mouthwash (Mouthwash with Herbal and Natural Extracts). Each assembly was placed in airtight containers. Four such containers were used for each group. In each container, 60 ml of respective mouthwash was poured. The samples were stored at room temperature for a total duration of 24 h. Samples were withdrawn at four different time intervals, which were at: 1, 6, 12, and 24 h.

At each time point, 10 ml of each mouthwash sample was collected and dispensed separately in airtight vials. Coding for each vial was done. Every collected sample was diluted in 1: 10 parts of distilled water to obtain a clear solution. The amount of nickel and chromium ion release was quantified using inductively coupled plasma-optical emission spectrometry (ICP-OES) (PERKIN ELMER OPTIMA 5300 DV ICP-OES, IIT). ICP-atomic emission spectroscopy, also referred to as ICP-OES, is an analytical technique used for the detection of chemical elements in trace amounts. Calibration was done by measuring the amount of nickel and chromium released using ICP-OES.

Results

The results showed an increase in the release of nickel and chromium ions in all mouthwashes. Nickel-ion release peaked at 24 h time with amflor mouthwash.

The lowest was recorded with herbal mouthwash. Considering the various time points, an initial increase in nickel release was noted with an Alcohol-based mouthwash, which further increased with time and then decreased [Table 1]. Release of nickel increased invariably with time. The chromium ion release was highest with a fluoride-based mouthwash out of four groups [Table 2]. The release of chromium was less with all types of mouthwashes in comparison to nickel.

Univariate ANOVA served to assess the effect of mouthwashes on the release of nickel and chromium ions from the orthodontic wires. The interaction of the variables was not significant with $P = 0.22$.

Discussion

Results of the present study demonstrated the release of nickel ions from the orthodontic assembly in all mouthwashes. The nickel levels were highest with a fluoridated mouthwash and minimum with an herbal mouthwash. However, the release of chromium ions was below detection levels during early hours of immersion with all mouthwashes and elevated with a fluoridated mouthwash after a 24 h immersion.

The contemporary study by Mirhashemi *et al*. evaluated the release of nickel and chromium from NiTi and SS wire with a whitening mouthwash. Their results showed the release of nickel and chromium ions from orthodontic wires in mouthwashes but not in distilled water.[11] This finding is in accordance with the results of the present study. They also reported that release from SS wires was less than that from NiTi wires. In the present study, therefore orthodontic assembly with NiTi wire alone was assessed for ion release.

Table 1: Release of nickel ions from orthodontic assembly at interval of 1, 6, 12, and 24 h

	1 h	6 h	12 h	24 h
Herbal mouthwash (mg/L)	0.003	0.008	0.007	0.009
Colgate plax (mg/L)	0.011	0.006	0.012	0.011
Listerine (mg/L)	0.013	0.015	0.010	0.014
Amflor (mg/L)	0.008	0.008	0.009	0.023

Table 2: Release of chromium ions from the orthodontic assembly at the interval of 1, 6, 12, and 24 h

Mouthwash	1 h	6 h	12 h	24 h
Herbal mouthwash	BDL	BDL	0.001 mg/L	BDL
Colgate plax (mg/L)	0.001	0.001	0.001	0.001
Listerine	BDL	BDL	0.001 mg/L	0.001 mg/L
Amflor	BDL	BDL	BDL	0.003 mg/L

BDL: Below detection limit

Danaei *et al*. in 2011 assessed the release of nickel and chromium ions from SS brackets in chlorhexidine and Oral B they noticed that this rate, being close to the threshold, was higher in chlorhexidine compared to that in other mouthwashes.[12] This demonstrated that ion release can shoot up in the presence of mouthwash and therefore, assembly of one full quadrant was assessed for ion leach in the presence of mouthwashes.

The effect of herbal mouthwashes on ion release from orthodontic assembly has been reported by several authors. Various herbal extracts have been used in different studies to assess for ion release from orthodontic wires, brackets, and molar tubes/bands. A study by Deriaty *et al*. assessed nickel ion release with chlorhexidine and herbal preparation containing Piper betle demonstrated low ion release with herbal preparation.[13] The results of the study were in line with the results of the current study, with the least nickel ion release from the herbal preparation. The study by Shruthi *et al*. which compared ion release from bonded and nonbonded orthodontic appliances also concluded that ion release was least with herbal mouthwash (HiOra) compared to chlorhex and fluoridated mouthwash.[14] Another study assessed corrosion resistance of NiTi wire when subjected to organic and inorganic mouthwashes. The least corrosion rate was reported with organic mouthwash when compared to inorganic mouthwashes (Listerine).[15] Contrasting results were reported by a study which concluded that ion release from orthodontic brackets was higher with herbal mouthwash.[16]

In the present study constituents such as purified water, sorbitol, alcohol, Poloxamer 407, sodium benzoate, sodium saccharine were common constituents of all mouthwashes except herbal mouthwash. Amine fluorine which is one of the main differentiating constituents of Amflor mouthwash thus can be said to be responsible for higher nickel release from fluoridated mouthwash due to its acidic nature leading to reduced pH of the Amflor mouthwash. Herbal mouthwash had menthol, thymol and extracts of tea tree oil, clove, ginger, nutmeg, and cardamom. The difference in basic constituents of herbal mouthwash compared to other mouthwashes can be a reason for decrease ion release with herbal mouthwash.

Petoumeno *et al*. found a slight but significant increase in the salivary nickel concentration of 78 µg. Immediately, after placement of the bands, brackets, and the NiTi archwires. In the present study, therefore frequent initial time points were taken to assess ion release.[17] A research paper published by Veverkova *et al*.[18] documented their *in vitro* study in which the human umbilical vein endothelial cells (HUVEC) were cultured in contact with the nitinol. The study for the first time described the presence of Ni ions released from nitinol directly in the cells. The release of Ni ions detected by ICP-MS in media collected after cultivation with the HUVEC cells showed an increasing trend with increasing time of contact with metal. This may elucidate that even though the levels are low below the threshold levels; direct contact can lead to nickel ion release in the cell and can lead to cytotoxic effects.

There are limitations to the present study. Differences in physiological conditions of the oral cavity and *in vitro* conditions, *in vivo* studies on this subject, and the use of artificial saliva are recommended to obtain more accurate results. Furthermore, due to the variability in rinses available over the counter, future studies using other mouthwashes are recommended. Furthermore, the mouthwashes were used for a continuous-time duration of 1 h, 6 h or so.

A time interval that represents an actual usage of mouthwash must be considered.

Conclusion

The use of mouthwash will increase in the release of nickel and chromium ions. Fluoridated Mouthwash causes the highest release of both nickel and chromium ions. Alcohol-based mouthwash caused the second-highest release of nickel ions followed by a nonalcoholic mouthwash. Herbal mouthwash caused the lowest release of both the ions. The levels ion detected was very low as compared to recommended dietary allowance, but direct contact may elicit a biological response. Choice of mouthwash, brackets, and wires therefore must be reconsidered in sensitized patients.

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Conflicts of interest

There are no conflicts of interest.

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