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Evaluating of Nickel and Chromium Ions Release from Orthodontic Wires After Use of Teeth Whitening Mouthwashes

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ABSTRACT

Background: Nickel (Ni) and chromium (Cr) ions are released from orthodontic wires due to corrosion, potentially causing allergic reactions and cytotoxic effects. Teeth-whitening mouthwashes contain active ingredients that may accelerate metal ion release. This study evaluates the release of Ni and Cr ions from orthodontic wires following exposure to different whitening mouthwashes.

Materials and Methods: A total of 60 stainless steel orthodontic wires were immersed in three different whitening mouthwashes (Group A, B, and C) and artificial saliva (control) for 30 days. Inductively coupled plasma-mass spectrometry (ICP-MS) was used to measure ion release at intervals of 7, 15, and 30 days. The pH and composition of the mouthwashes were analyzed to determine their corrosive potential.

Results: Nickel and chromium ion release was significantly higher in all test groups compared to the control. Group A showed the highest Ni release (4.2 ± 0.3 µg/L), followed by Group B (3.5 ± 0.4 µg/L) and Group C (2.8 ± 0.2 µg/L), while the control had the lowest (1.2 ± 0.1 µg/L). Similarly, Cr release was highest in Group A (2.1 ± 0.2 µg/L), followed by Group B (1.8 ± 0.3 µg/L), and Group C (1.5 ± 0.2 µg/L), whereas the control exhibited the lowest release (0.7 ± 0.1 µg/L). A statistically significant increase in ion release was observed over time ($p < 0.05$).

Conclusion: Whitening mouthwashes contribute to increased release of Ni and Cr ions from orthodontic wires, with variations depending on their composition and pH. Prolonged exposure may pose biocompatibility concerns, highlighting the need for patients undergoing orthodontic treatment to use whitening mouthwashes cautiously.

Keywords: *Nickel release, chromium release, orthodontic wires, whitening mouthwash, corrosion, biocompatibility.*

1. INTRODUCTION

Orthodontic appliances, particularly stainless steel wires, are commonly used in fixed orthodontic treatments due to their mechanical strength, corrosion resistance, and biocompatibility (1). However, these wires contain metal alloys composed mainly of nickel (Ni) and chromium (Cr), which may be released into the oral environment due to corrosion and degradation processes (2,3). This metal ion release can be influenced by various factors, including pH fluctuations, temperature, and exposure to oral hygiene products such as mouthwashes (4).

Whitening mouthwashes have gained popularity due to their ability to enhance tooth aesthetics by reducing extrinsic stains (5). These formulations often contain hydrogen peroxide, carbamide peroxide, or acidic components that may accelerate the corrosion of orthodontic wires, leading to increased Ni and Cr ion release (6). Previous studies have reported that metal ion release from orthodontic appliances is influenced by the acidity and composition of mouthwashes, raising concerns about their long-term effects on both the structural integrity of wires and patient health (7,8). Prolonged exposure to Ni and Cr ions can induce hypersensitivity reactions, cytotoxicity, and even potential genotoxic effects in some individuals (9).

Although several studies have evaluated the corrosion behavior of orthodontic appliances in various oral environments, limited research has focused specifically on the effect of whitening mouthwashes on Ni and Cr ion release (10). Given the widespread use of these products among orthodontic patients, it is essential to assess their impact on the degradation of orthodontic wires. This study aims to evaluate the release of Ni and Cr ions from stainless steel orthodontic wires after exposure to different teeth-whitening mouthwashes to determine their potential biocompatibility risks.

2. MATERIALS AND METHODS

Study Design

This in vitro study evaluated the release of nickel (Ni) and chromium (Cr) ions from stainless steel orthodontic wires after immersion in different teeth-whitening mouthwashes. The experiment was conducted over 30 days, with ion release measured at regular intervals.

Sample Selection and Grouping

A total of 60 stainless steel orthodontic wires (0.019 × 0.025-inch) were divided into four groups (n = 15 per group):

- **Group A:** Wires immersed in Whitening Mouthwash A
- **Group B:** Wires immersed in Whitening Mouthwash B
- **Group C:** Wires immersed in Whitening Mouthwash C
- **Control Group:** Wires immersed in artificial saliva

Preparation of Test Solutions

Three commercially available whitening mouthwashes with different compositions were selected. Their pH levels were measured using a digital pH meter before the experiment. Artificial saliva was used as a control solution to simulate normal oral conditions.

Experimental Procedure

Each orthodontic wire was placed in a sterile test tube containing 10 mL of the respective test solution. The tubes were incubated at **37°C** to mimic intraoral conditions. Ion release measurements were conducted at three time points: **7, 15, and 30 days**. The test solutions were replaced every 48 hours to maintain consistency.

Ion Release Measurement

The amount of Ni and Cr ions released into the solutions was analyzed using **Inductively Coupled Plasma Mass Spectrometry (ICP-MS)**. Before testing, each sample was filtered and acid-digested to ensure accurate detection of metal ions.

Statistical Analysis

The data were analyzed using **one-way ANOVA**, followed by **Tukey's post-hoc test** to compare differences between groups. A **p-value < 0.05** was considered statistically significant. All statistical analyses were performed using **SPSS software (version 26, IBM Corp., USA)**.

3. RESULTS

The release of nickel (Ni) and chromium (Cr) ions was measured in different groups over a period of 30 days. The data indicate a significant increase in ion release in the whitening mouthwash groups compared to the control group.

Nickel Ion Release

Table 1 presents the nickel ion release at different time intervals. The highest Ni release was observed in Group A, reaching **4.2 ± 0.3 µg/L** by the 30th day, followed by Group B (**3.5 ± 0.4 µg/L**) and Group C (**2.8 ± 0.2 µg/L**). The control group exhibited the least release, measuring **1.2 ± 0.1 µg/L**. A statistically significant increase was noted in all test groups over time (**p < 0.05**).

Chromium Ion Release

As shown in Table 2, chromium ion release followed a similar trend, with the highest levels detected in Group A (**2.1 ± 0.2**

µg/L) at 30 days, followed by Group B (**1.8 ± 0.3 µg/L**) and Group C (**1.5 ± 0.2 µg/L**). The control group recorded the lowest Cr release (**0.7 ± 0.1 µg/L**). The increase in ion release was statistically significant over time (**p < 0.05**).

Tables

Table 1: Nickel Ion Release (µg/L) Over Time in Different Groups

Time (Days)	Control	Group A	Group B	Group C
7	0.5 ± 0.1	1.8 ± 0.2	1.5 ± 0.2	1.1 ± 0.1
15	0.8 ± 0.1	3.0 ± 0.3	2.5 ± 0.3	1.9 ± 0.2
30	1.2 ± 0.1	4.2 ± 0.3	3.5 ± 0.4	2.8 ± 0.2

(*p < 0.05 for intergroup comparison*)

Table 2: Chromium Ion Release (µg/L) Over Time in Different Groups

Time (Days)	Control	Group A	Group B	Group C
7	0.3 ± 0.1	1.0 ± 0.1	0.9 ± 0.2	0.6 ± 0.1
15	0.5 ± 0.1	1.5 ± 0.2	1.3 ± 0.2	1.0 ± 0.1
30	0.7 ± 0.1	2.1 ± 0.2	1.8 ± 0.3	1.5 ± 0.2

(*p < 0.05 for intergroup comparison*)

The findings indicate that whitening mouthwashes significantly enhance Ni and Cr ion release from orthodontic wires, with Group A showing the highest corrosion effect (Table 1 and Table 2).

4. DISCUSSION

The present study evaluated the release of nickel (Ni) and chromium (Cr) ions from stainless steel orthodontic wires following exposure to different teeth-whitening mouthwashes. The findings indicate a significant increase in ion release over time in the test groups compared to the control, suggesting that the chemical composition of whitening mouthwashes may accelerate corrosion of orthodontic wires.

Nickel and chromium are primary components of stainless steel orthodontic wires, with nickel improving mechanical properties and chromium enhancing corrosion resistance (1). However, exposure to oral fluids, especially those with acidic components, can cause metal ion release due to electrochemical reactions on the wire surface (2). Previous studies have demonstrated that the oral environment, including factors such as temperature fluctuations, salivary pH, and exposure to dental products, influences the extent of ion release (3,4). Our findings are consistent with earlier research showing that acidic and peroxide-based mouthwashes can alter the corrosion resistance of orthodontic alloys (5).

The results indicate that Group A exhibited the highest release of Ni and Cr ions, followed by Group B and Group C, while the control group showed the least ion release. This suggests that the composition and pH of whitening mouthwashes play a critical role in accelerating corrosion. Studies have reported that mouthwashes containing hydrogen peroxide and other oxidizing agents may degrade the passivation layer of stainless steel, thereby increasing metal ion release (6,7). The lower pH of some whitening mouthwashes may further enhance corrosion by increasing surface roughness and disrupting the protective oxide layer of orthodontic wires (8).

The health implications of Ni and Cr ion release are noteworthy. Nickel is a well-documented allergen and has been associated with hypersensitivity reactions, dermatitis, and cytotoxic effects (9). Chromium, while generally stable in stainless steel alloys, may cause cellular toxicity in its hexavalent form (10). Long-term exposure to metal ions from orthodontic appliances has also been linked to potential genotoxicity and systemic toxicity (11,12). The observed increase in ion release over time in our study reinforces concerns regarding prolonged use of whitening mouthwashes in orthodontic patients.

The findings align with previous studies that reported increased corrosion and ion release in orthodontic appliances exposed to fluoride- and peroxide-containing mouthwashes (13,14). Additionally, researchers have highlighted the role of fluoride, commonly found in mouthwashes, in enhancing corrosion through complex interactions with metal surfaces (15). However, despite the increased ion release observed in our study, the concentrations remained below toxic levels reported in the literature (16).

This study has some limitations. Firstly, the in vitro conditions do not fully replicate the complex oral environment, where factors such as salivary flow, bacterial biofilm formation, and dietary variations may influence corrosion. Secondly, only three whitening mouthwashes were tested, and results may vary with different formulations. Future studies should investigate the long-term effects of whitening mouthwashes in clinical settings and explore potential protective coatings to minimize corrosion.

5. CONCLUSION

The study demonstrates that teeth-whitening mouthwashes significantly increase the release of Ni and Cr ions from orthodontic wires, with variations depending on their composition and pH. Patients undergoing orthodontic treatment should be advised on the cautious use of whitening mouthwashes to minimize potential biocompatibility risks.

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