RESEARCH PAPER

INFLUENCE OF RHODIUM COATING ON FLUORIDE-INDUCED CORROSION OF STAINLESS-STEEL ORTHODONTIC ARCHWIRES

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ABSTRACT

Background: Stainless-steel archwires are widely used in orthodontics because of their favorable mechanical properties and generally good corrosion resistance. However, exposure to fluoride-containing oral hygiene products may alter their surfaces and affect corrosion behavior, particularly under unfavorable chemical conditions. Rhodium, a noble metal, is used as an esthetic surface coating and may provide a barrier between the underlying alloy and the surrounding environment.

Aim: To evaluate the influence of rhodium coating on fluoride-induced corrosion of stainless steel orthodontic archwires under simulated oral conditions**.**

Materials and Methods: Forty stainless-steel archwire specimens were allocated to four groups (n = 10 per group): rhodium-coated wires in artificial saliva, rhodium-coated wires exposed to fluoride, uncoated wires in artificial saliva, and uncoated wires exposed to fluoride. The specimens were immersed in modified Fusayama artificial saliva, with the fluoride-exposed groups receiving 0.02% fluoride-containing mouthwash, and incubated at 37°C for 12 weeks. Surface changes were examined using stereomicroscopy and scanning electron microscopy (SEM). The source thesis does not clearly define the unit or quantitative method for the reported corrosion outcome; this must be verified before submission.

Results: The mean reported corrosion values were 60.50 ± 2.80 for rhodium-coated stainless steel without fluoride and 58.00 ± 1.83 after fluoride exposure. The corresponding values for uncoated stainless steel were 27.00 ± 4.22 and 164.00 ± 4.85. The source thesis reports within-group comparisons of $t = 2.366$, $p = 0.029$ for rhodium-coated stainless steel and $t = -67.386$, $p < 0.001$ for uncoated stainless steel. Because the unit and calculation method are unclear, these values should be described as the reported corrosion outcome rather than as a standardized corrosion rate.

Conclusion: In this in-vitro study, fluoride exposure was associated with a marked increase in the reported corrosion outcome for uncoated stainless-steel archwires, whereas the value for rhodium-coated wires changed only slightly. The outcome unit and quantitative method require clarification before any claim of clinical protection can be made.

Keywords: Stainless-steel archwires; rhodium coating; fluoride; corrosion; orthodontic biomaterials; artificial saliva; surface modification.

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INTRODUCTION

Orthodontic archwires are essential components of fixed appliances because they deliver biomechanical forces to the dentition. Stainless steel remains an important archwire alloy because of its stiffness, formability, surface characteristics, and clinical versatility. Nevertheless, the intraoral environment is chemically dynamic; saliva, microorganisms, dietary substances, and oral hygiene products can interact with metallic surfaces.

Corrosion is an electrochemical process involving interactions between a metallic material and its environment. In orthodontic appliances, corrosion may produce surface changes, alter mechanical properties, and contribute to metal-ion release. Stainless steel generally develops a chromium-rich passive oxide layer that provides substantial protection; however, this layer is not completely immune to environmental attack.

Fluoride is routinely used in oral hygiene products for caries prevention. From a materials perspective, fluoride may affect the stability of protective surface films, particularly under unfavorable pH conditions. Previous studies have reported increased corrosion and surface degradation of orthodontic wires after

exposure to fluoride-containing solutions; the specific supporting references should be checked against the original publications.

Surface coating is one strategy for improving the environmental stability of orthodontic archwires. Rhodium is a noble metal with high chemical stability and resistance to oxidation. A continuous rhodium layer may reduce direct contact between the underlying stainless steel and the surrounding electrolyte, thereby attenuating fluoride-associated corrosion.

This article reports only the stainless-steel subgroup of the 80-specimen source study. The nickel–titanium groups are not included in this analysis, and conclusions should therefore be restricted to the stainless-steel specimens.

1. AIM

To evaluate the influence of rhodium coating on fluoride-induced corrosion of stainless steel orthodontic archwires under simulated oral conditions**.**

2. OBJECTIVES

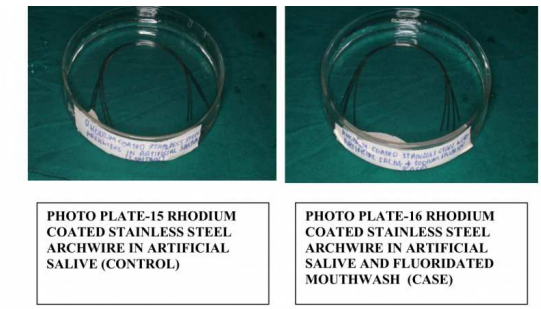
- To evaluate corrosion of rhodium-coated stainless steel archwires in artificial saliva.
- To evaluate corrosion of rhodium-coated stainless-steel archwires following fluoride exposure
- To evaluate corrosion of uncoated stainless steel archwires in artificial saliva.
- To evaluate corrosion of uncoated stainless-steel archwires following fluoride exposure.
- To compare the change in corrosion produced by fluoride between rhodium-coated and uncoated stainless steel archwires.

3. MATERIALS AND METHODS

4.1 Study design and specimens

This was an in-vitro experimental study. The stainless-steel specimens were 0.019 × 0.025-inch rhodium-coated archwires and 0.019 × 0.025-inch uncoated archwires, . All wires were new and unused; deformed, previously used, and recycled wires were excluded. Because the wires came from different manufacturers, differences in alloy composition, manufacturing, and surface finishing may confound the comparison.

Figure 1. Rhodium-coated stainless steel archwire specimens used in the source study



4.2. Experimental groups

S.No	Group	Surface	Environment	n
1	RC-control	Rhodium-coated SS	Artificial saliva	10
2	RC-Fluoride	Rhodium-coated SS	Artificial saliva + 0.02% fluoride	10
3	UC-control	Uncoated SS	Artificial saliva	10
4	UC-Fluoride	Uncoated SS	Artificial saliva + 0.02% fluoride	10

Note: RC = rhodium-coated; UC = uncoated; SS = stainless steel.

4.3. Artificial saliva and fluoride exposure

Modified Fusayama artificial saliva was prepared using sodium chloride (0.4 g), potassium chloride (0.4 g), calcium chloride dihydrate (0.8 g), sodium sulfide pentahydrate (0.01 g), urea (1 g), and distilled water (1 L), as reported in the source thesis. The pH was adjusted to 7. The experimental groups were exposed to 0.02% fluoride-containing mouthwash (Listerine Total Care) and incubated at 37°C for 12 weeks. Before submission, confirm whether 0.02% refers to the final immersion solution or the commercial mouthwash concentration, and specify the solution-refresh schedule and exposure protocol if recorded.

4.4. Corrosion assessment

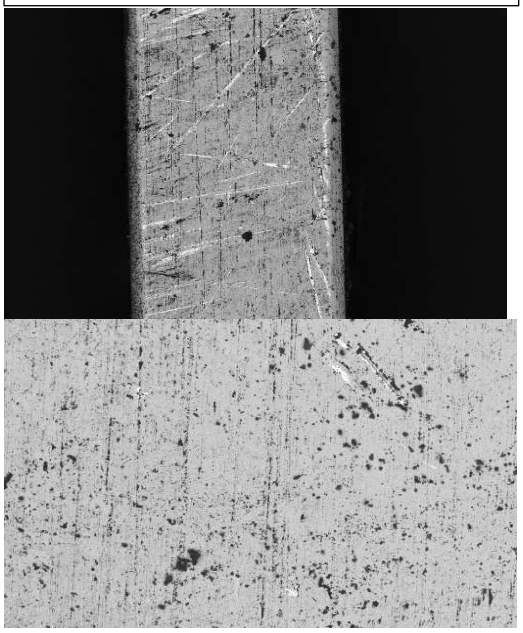
After immersion, the wires were cut into 5-mm segments. Surface changes were assessed using a stereomicroscope at 100× magnification and SEM at 100× magnification, according to the source thesis. The thesis does not clearly describe a validated quantitative method for deriving the reported corrosion values. The measurement method, scoring or calculation system, and units must be clarified from the original laboratory records.

Figure 2. Stereomicroscope and scanning electron microscope used for corrosion assessment



STAINLESS STEEL ARCHWIRES IN ARTIFICIAL SALIVA WITH SODIUM FLUORIDE(CASE)

STAINLESS STEEL ARCHWIRES IN ARTIFICIAL SALIVA WITHOUT SODIUM FLUORIDE(CONTROL)



RHODIUM COATED STAINLESS STEEL ARCHWIRES IN ARTIFICIAL SALIVA WITH SODIUM FLUORIDE(CASE)

RHODIUM COATED STAINLESS STEEL ARCHWIRES IN ARTIFICIAL SALIVA WITHOUT SODIUM FLUORIDE(CONTROL)

4. RESULTS

The stainless-steel subgroup results are summarized in Table 2. Group means and standard deviations are transcribed from the source thesis. The thesis uses the terms “corrosion” and “corrosion area” but does not clearly define the unit or the procedure used to derive the numerical outcome. This information must be confirmed from the original laboratory records.

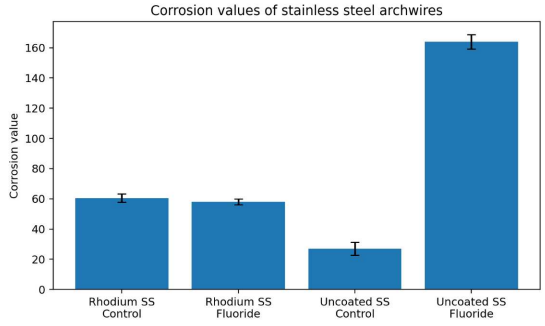
Group	n	Mean reported value	SD	Change vs control	t value	p value
Rhodium-coated SS – control	10	60.50	2.80	Reference	—	—
Rhodium-coated SS – fluoride	10	58.00	1.83	−2.50	2.366	0.029
Uncoated SS – control	10	27.00	4.22	Reference	—	—
Uncoated SS – fluoride	10	164.00	4.85	+137.00	−67.386	<0.001

Table 2. Reported corrosion outcome in the stainless-steel subgroups. Values are mean ± SD; n = 10 per group. The change is calculated as the fluoride-group mean minus the corresponding control mean. The source thesis does not clearly specify the outcome unit or calculation method. t and p values are reproduced from the thesis and require confirmation against the original SPSS output.

For rhodium-coated stainless steel, the reported mean decreased from 60.50 ± 2.80 in fluoride-free artificial saliva to 58.00 ± 1.83 after fluoride exposure. The source thesis reports t = 2.366 and p = 0.029. The exact statistical test, degrees of freedom, and analysis assumptions should be checked against the original SPSS output before submission.

For uncoated stainless steel, the reported mean increased from 27.00 ± 4.22 to 164.00 ± 4.85 after fluoride exposure; the source thesis reports t = −67.386 and p < 0.001. Under fluoride exposure, the descriptive difference between the uncoated and rhodium-coated group means was 106 reported units (164.00 − 58.00). This is a descriptive comparison and should not be presented as statistically significant unless a direct pairwise test supports it.

The source thesis reports an overall one-way ANOVA across all eight study groups (F = 1473.35, p < 0.001). Because this analysis includes nickel–titanium groups, it is not a stainless-steel-only analysis and is not used as the primary inferential result in this focused article. Verify this statistic against the original statistical output.



5. DISCUSSION

The principal descriptive finding was that the reported outcome changed differently in coated and uncoated stainless-steel archwires after fluoride exposure. The mean increased markedly in the uncoated group and decreased slightly in the rhodium-coated group. Interpretation is limited by the unclear definition and units of the measured outcome.

These findings are consistent with the role of passive-film protection in stainless steel. Stainless steel relies on a chromium-rich passive layer for corrosion resistance. Conditions that destabilize or damage this layer may permit greater electrochemical interaction between the alloy and its surrounding medium.

The source thesis identifies fluoride as a potential environmental factor in orthodontic corrosion and discusses the possibility of increased surface degradation, particularly under acidic conditions. In the present stainless-steel subgroup, the fluoride-associated increase in the measured corrosion value was much greater in the uncoated group.

Rhodium may provide a barrier between the stainless-steel substrate and the surrounding electrolyte. The relatively stable value in the rhodium-coated group after fluoride exposure is consistent with the possibility that the coating attenuated environmental interaction. However, the fluoride-free rhodium-coated group had a higher absolute measured value than the fluoride-free uncoated group. Therefore, these data do not show that rhodium coating universally produces the lowest corrosion value; rather, they suggest that the fluoride-associated increase was attenuated in the coated group. This interpretation depends on confirmation of the corrosion measurement method and units.

This distinction is important because corrosion behavior may depend on alloy composition, manufacturer, surface finish, coating thickness, coating integrity, and test method. Coating performance may also depend on oral environmental conditions and coating durability.

6. CLINICAL RELEVANCE

Patients undergoing fixed orthodontic treatment commonly use fluoride-containing toothpastes and mouthwashes. These in-vitro findings may justify further investigation of the surface behavior of coated and uncoated stainless-steel wires. However, the unclear outcome definition and the use of wires from different manufacturers mean that this study does not establish a clinical protective benefit of rhodium coating. The results should not be used to recommend avoiding fluoride-containing oral hygiene products, which are important for caries prevention.

7. LIMITATIONS

- The study was performed in vitro and could not fully reproduce salivary flow, microbial activity, mastication and dynamic temperature/pH changes.
- Only one fluoride exposure protocol was evaluated.
- The stainless steel wires were obtained from different manufacturers, creating a potential confounding effect from alloy composition, manufacturing process and surface finishing.
- Only 10 specimens were present in each stainless-steel subgroup.
- Metal-ion release was not directly quantified in this stainless-steel analysis.

8. FUTURE SCOPE

- Use rhodium-coated and uncoated stainless steel wires from the same manufacturer and alloy batch.
- Evaluate multiple fluoride concentrations and different mouthwash formulations.
- Compare neutral and acidic fluoride environments.
- Use SEM/EDX, AFM and electrochemical impedance spectroscopy for detailed surface and corrosion analysis.
- Quantify nickel, chromium and iron ion release.

- Assess coating thickness, adhesion, wear and microcrack formation after mechanical loading.
- Conduct long-term clinical or in-vivo investigations.

9. CONCLUSION

In this in-vitro study, fluoride exposure was associated with an increase in the reported corrosion outcome for uncoated stainless-steel archwires (27.00 ± 4.22 to 164.00 ± 4.85), whereas the value for rhodium-coated wires changed from 60.50 ± 2.80 to 58.00 ± 1.83. These findings indicate different observed responses between the groups but do not, by themselves, establish that rhodium coating provides clinically meaningful corrosion protection. The outcome unit and quantitative method must be clarified, and the use of wires from different manufacturers is a potential confounder. Further standardized corrosion testing and long-term investigations are needed.

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