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Impact of Rexidin SRS mouthwash on the corrosion characteristics ofNi-Cr orthodontic wire submerged in artificial saliva

ABSTRACT

Teeth that are properly aligned are considered attractive; however, some individuals possess naturally irregular teeth alignment. To address this issue, orthodontists utilize wires. Once the wires are installed, patients consume a variety of foods, drink beverages, and take tablets orally, which may pose a risk to the wires. Additionally, the wires are susceptible to corrosion when they come into contact with saliva. This study examined the corrosion resistance of orthodontic wires made from thermo-active alloy in artificial saliva, both with and without the inclusion of Rexidin SRS mouthwash, through a polarization analysis. The corrosion characteristics of the Ni-Cr alloy were evaluated for two systems: the Artificial Saliva system and the Artificial Saliva combined with Rexidin SRS mouthwash system. The experiment involved measuring Linear Polarization Resistance (LPR) and corrosion current values.The study produced the subsequent results. The ranking of corrosion resistance in Ni-Cr alloy orthodontic wire is as follows: Artificial Saliva > Artificial Saliva in conjunction with Rexidin SRS mouthwash. This indicates that individuals using Ni-Cr orthodontic wire ought to avoid the use of Rexidin SRS mouthwash.

Keywords: *Corrosion resistance, Orthodontic wire, Ni-Cr, Artificial Saliva, Rexidin SRS mouthwash*

1. INTRODUCTION

Objects that exhibit symmetry inherently embody beauty. The existence of symmetry is crucial for the appreciation of beauty. This symmetry is a result of a uniform arrangement. When teeth are correctly aligned, they create appealing smiles that attract others. Regrettably, not everyone is fortunate enough to have well-aligned teeth. Attaining proper dental alignment necessitates the expertise of dentists, who utilize orthodontic wires crafted from various alloys, such as SS 316 L, SS 18/9, NiTi, and NiCr. Following the adjustment of these wires, individuals frequently consume a variety of tablets, foods, and juices, which may result in the corrosion of the orthodontic wires.

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Furthermore, within the oral cavity, saliva—which is composed of 98% water in addition to electrolytes, mucus, white blood cells, epithelial cells (from which DNA can be obtained), glycoproteins, enzymes (including amylase and lipase), and antimicrobial substances such as secretory IgA and lysozyme—exacerbates the deterioration of orthodontic wires.

A multitude of research studies have been conducted to assess the corrosion resistance of various orthodontic wires when exposed to artificial saliva along with food items, tablets, juices, and candies.

A multitude of researchers [1-10] have explored the corrosion characteristics of orthodontic wires when immersed in artificial saliva. The following is a summary of several of these investigations.

Karandish et al. [1] conducted a study examining the corrosion characteristics of orthodontic wires composed of zinc-coated stainless steel. They assessed the impact of the

physical vapor deposition method. The corrosion behavior of both zinc-coated and uncoated stainless steel wires was analyzed in neutral and acidic conditions utilizing electrochemical impedance spectroscopy (EIS), potentiodynamic polarization tests, and Tafel analysis.

The utilization of a zinc coating on uncoated stainless steel orthodontic wire via the physical vapor deposition technique may improve the corrosion resistance of the underlying stainless steel substrate [1].

The research entitled "Corrosion Analysis of Orthodontic Brackets and Arch Wires – An in vitro Study" was carried out by Wijesinghe et al.[2]. Orthodontic appliances are affixed to the teeth in the ever-changing environment of the oral cavity.

The orthodontic devices, encompassing both brackets and arch wires, are subjected to different pH levels found in the oral cavity. These devices are constructed from metal alloys that comprise nickel, iron, cadmium, and titanium. This study suggests that all brands of brackets examined may contribute to the onset of nickel hypersensitivity as time progresses [2].

The influence of Copper Barrel brandy on the corrosion properties of Ni-Ti orthodontic wire immersed in artificial saliva has been examined by Vinnarasi[3]. The corrosion resistance of orthodontic wire composed of Ni-Ti alloy has been evaluated using polarization studies and AC impedance spectroscopy, conducted in artificial saliva both with and without the presence of Copper Barrel brandy.

The findings indicate a reduction in the corrosion resistance of the Ni-Ti alloy when exposed to artificial saliva containing Copper Barrel brandy. Therefore, it is advised that individuals with orthodontic wires composed of Ni-Ti alloy refrain from consuming Copper Barrel brandy [3].

Umamathi et al.[4] performed electrochemical studies to investigate the corrosion properties of orthodontic wire made from thermo-active super elastic (TASE) alloy when submerged in artificial saliva, particularly in the presence of a mouthwash called Colgate Max Fresh. The corrosion metrics, including charge transfer resistance (Rt), impedance, and double layer capacitance (Cdl), were obtained from AC impedance spectra. The effect of Colgate Max Fresh mouthwash on the corrosion resistance of TASE in artificial saliva has been evaluated, and the values of the corrosion parameters have been compared. Furthermore, surface morphology was analyzed using SEM and AFM techniques [4].

The corrosion characteristics of SS 18/8 orthodontic wire in artificial saliva, when subjected to an aqueous extract of Spillanthesacmella leaves, have been examined by Begum et al.[5]. To conduct this evaluation, electrochemical methods including polarization techniques and AC impedance spectroscopy have been utilized.

The protective layer that forms on the wire has been analyzed using FTIR and AFM techniques. FTIR spectral analysis indicates that the observed enhancement in corrosion resistance results from the adsorption of active compounds from the leaf extract onto the metal surface [5].

Sufarnap et al.[6] carried out a research study on the corrosion of copper nickel titanium archwire when exposed to chlorhexidine, sodium fluoride, and chitosan mouthwashes. The assessment of the corrosion of the samples was conducted utilizing an atomic absorption spectrophotometer (AAS), a scanning electron microscope (SEM), and a universal testing machine (UTM). The results of the study reveal that the release of nickel ions escalated over time, while the release of copper ions decreased throughout the observation period [6].

Begum et al. [7] conducted a study on the prevention of corrosion in orthodontic wires composed of SS 18/8 alloy by using esomeprazole tablets (Esiloc-40 mg) in artificial saliva. The results of this research indicate that patients with orthodontic wires made from SS 18/8 alloy can be assured of a diminished risk of orthodontic corrosion when utilizing esomeprazole tablets for the management of gastroesophageal reflux disease and other medical conditions [7].

The effects of various coating methods on the mechanical, physical, and aesthetic properties of GUMMETAL® archwires have been examined by Zhou et al. [8]. This in vitro research involved 180 orthodontic wires, categorized into five experimental groups, utilizing 0.016 × 0.022-inch GM as the core wire, which were subsequently coated with epoxy, polytetrafluoroethylene (PTFE), clear ceramic, white ceramic, or silicone.

The findings indicate that while applying a coating to the wires may enhance specific characteristics, it does not automatically improve every aspect when juxtaposed with uncoated GM and SS. Further investigation into the materials utilized in this research is necessary to more precisely delineate their properties [8].

Sahoo et al.[9] performed a study examining the In Vitro Effects of Fluoride Prophylactic Agents on Titanium Molybdenum Alloy and Stainless Steel Orthodontic Wires. The results indicate that orthodontists ought to refrain from allowing orthodontic wires with titanium protective coatings to come into contact with prophylactic agents [9].

The study conducted by Anitha et al. [10] examined the corrosion resistance of orthodontic wire made from 18K gold alloy in artificial saliva, especially in the presence of Éclairs milky candy. This research focused on assessing the corrosion resistance of the 18K gold alloy orthodontic wire when immersed in artificial saliva, comparing conditions with and without the inclusion of 500 ppm of Éclairs milky candy, employing polarization studies and AC impedance spectroscopy.

The results indicate that the corrosion resistance of the 18K gold alloy is enhanced in the presence of 500 ppm of Éclairs milky candy. Consequently, individuals with orthodontic wires composed of 18K gold alloy can safely indulge in Éclairs milky candy without any concerns [10].

The current research seeks to examine the corrosion resistance of a Ni-Cr alloy in artificial saliva, analyzing the effects both in the presence and absence of Rexidin SRS Mouth Wash, utilizing polarization analysis.

2. EXPERIMENTAL PROCEDURE

Ni-Cr alloy

The Ni-Cr alloy consists of Ni(75%), Fe(12%), Cr(11%), and Mn(2%). The working electrode was enclosed in a Teflon rod (Invento), underwent polishing to attain a mirror-like finish, and was employed for electrochemical studies.

Preparation of artificial saliva

The preparation of artificial saliva was conducted using the Fusayama Meyer artificial saliva (AS) formulation. The artificial saliva was created in a laboratory environment, and its formulation comprised the following elements:KCl – 0.4 g/L, NaCl – 0.4 g/L, $CaCl_2.2H_2O$ – 0.906 g/L, $NaH_2PO_4.2H_2O$ – 0.690 g/L, $Na_2S.9H_2O$ – 0.005 g/L, urea – 1 g/L. The solution exhibited a pH level of 6.5.

Rexidin SRS Mouth Wash

How to use Rexidin Mouth Wash

Please verify the label prior to usage.Measure the mouthwash according to your doctor's recommendations and place it in your mouth. Rinse for a duration of 30 seconds to 1 minute, then expel it. Do not ingest. Refrain from consuming food, beverages, or smoking for a minimum of 30 minutes following the rinsing process (Figure 1).

How Rexidin Mouth Wash works

Rexidin SRS Mouth Wash is an antiseptic that adheres firmly to the surfaces of teeth, inner cheeks, and gums.It functions by eliminating the harmful microorganisms responsible for swollen gums, tartar buildup, unpleasant mouth odor, and various oral infections.

SALT COMPOSITION

ChlorhexidineGluconate (0.2% w/v)[11]

Rexidin SRS Mouth Wash is utilized for the treatment of gum inflammation. It eliminates harmful microorganisms present in the oral cavity that lead to swollen gums, tartar buildup, and unpleasant mouth odor. In this manner, it cleanses the affected region and accelerates the healing process.

How Rexidin Mouth Wash works

Rexidin SRS Mouth Wash is an antiseptic that adheres firmly to the surfaces of teeth, inner cheeks, and gums.It functions by eliminating the harmful microorganisms responsible for swollen gums, tartar buildup, unpleasant mouth odor, and various oral infections.



Figure 1. Rexidin SRS mouthwash

Potentiodynamic polarization technique

A CHI 660 A workstation model was utilized for the electrochemical investigations. The polarization study was carried out using a three-electrode cell configuration (see Figure 2).

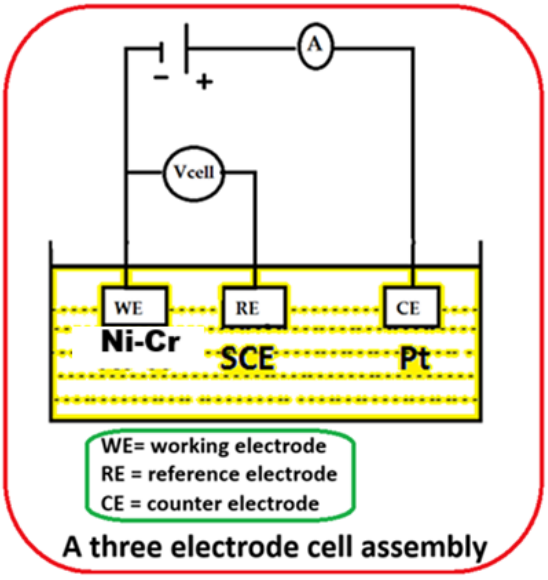


Figure 2. A Three electrode cell assembly

The working electrode was made of a Ni-Cr alloy, while a platinum electrode acted as the counter electrode, and a saturated calomel electrode (SCE) was employed as the reference electrode. After applying iR compensation, the polarization study was conducted at a sweep rate of 0.01 V/sec.

The corrosion parameters, which encompass linear polarization resistance (LPR), corrosion potential (Ecorr), corrosion current (Icorr), and Tafel slopes (ba and bc), were evaluated.

3. RESULTS AND DISCUSSION

Electrochemical studies

Electrochemical studies, which encompass polarization analysis and AC impedance spectroscopy, have been widely utilized to evaluate the corrosion resistance of metals and alloys across various environments [12-20].

Polarization study

The polarization curves for the orthodontic wire composed of Ni-Cr alloy, when submerged in artificial saliva both in the absence and presence of Rexidin SRS mouthwash, are depicted in Figures 3 and 4.

The various corrosion parameters, such as Corrosion Current, Linear Polarization Resistance, Tafel Slopes (bc for cathodic and ba for anodic), and Corrosion Potential (Ecorr), are detailed in Table 1. A decline in corrosion resistance correlates with a reduction in the LPR value and a rise in the corrosion current, as demonstrated in Figure 5.

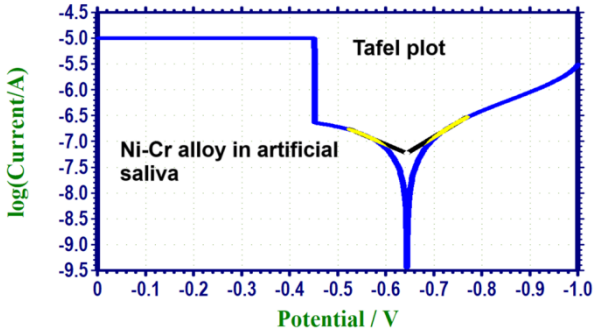


Figure 3. Tafel plot of Ni-Cr alloy in artificial saliva

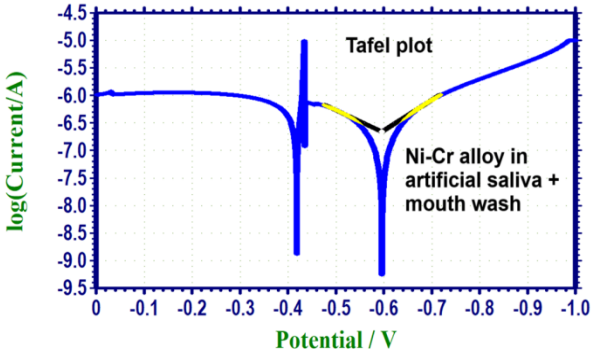


Figure 4. Tafel plot of Ni-Cr alloy in artificial saliva + Rexidin SRS mouthwash

It can be seen from Figure 3 that when the Ni-Cr alloy is submerged in artificial saliva, the film ruptures at -460 mV. Following this, there is a sudden rise in the corrosion current value. Subsequently, a passive region is noted.

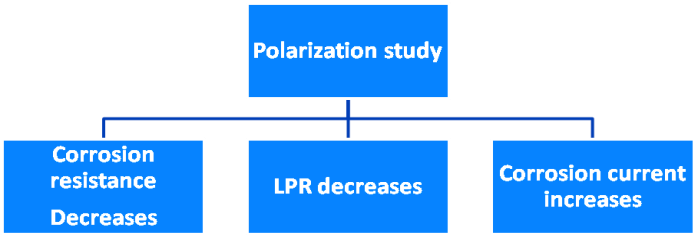


Figure 5. Analysis of the relationship between corrosion parameters obtained from polarization studies.

Table 1. The corrosion parameters of Ni-Cr alloy immersed in artificial saliva in the absence and presence of Rexidin mouthwash

System	E_{corr}, mV vsSCE	b_c, mV/decade	b_a mV/decade	LPR Ohm/cm^2	I_{corr}, A/cm^2
AS	-644	177	255	552959	8.202×10^{-8}
AS+ Rexidin mouthwash	-596	180	245	149840	30.12×10^{-8}
observant ion	Shift is almost within 50 mV			decreases	increases
Inference	Mixed type shift Anodic reaction and cathodic reaction accelerated to an equal extent			Corrosion resistance decreases	Corrosion resistance decreases
Implication	Individuals with orthodontic wires composed of Ni-Cr alloy are advised to refrain from using Rexidin SRS mouthwash				

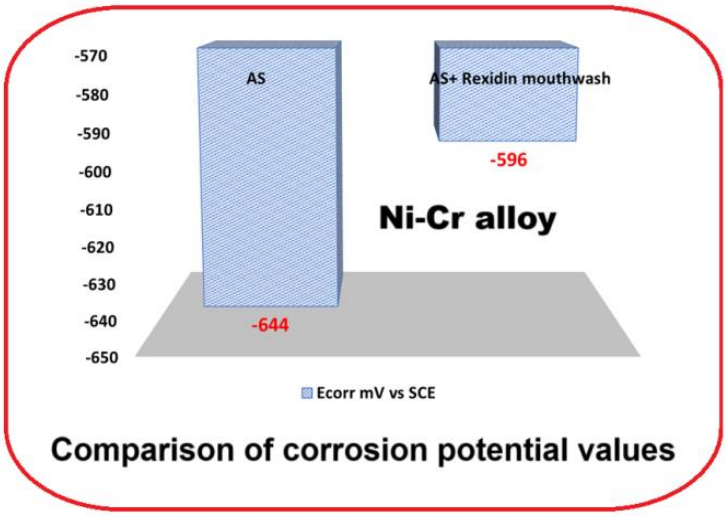


Figure 6. Comparison of corrosion potential values of Ni-Cr alloy

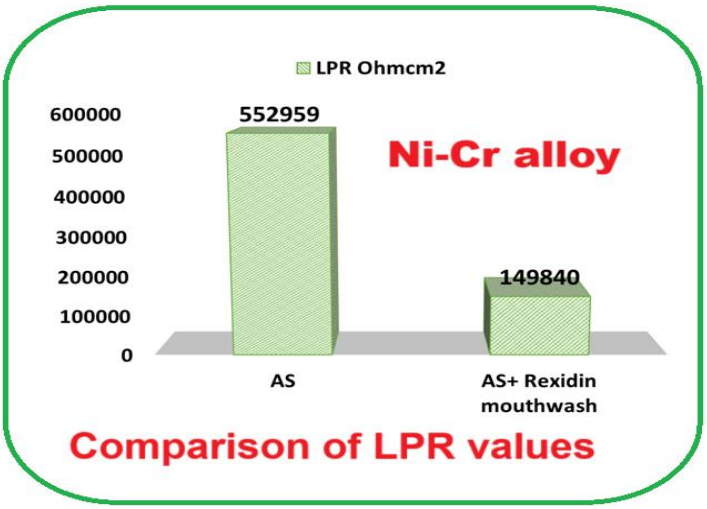


Figure 7. Comparison of linear polarization resistance values of Ni-Cr alloy

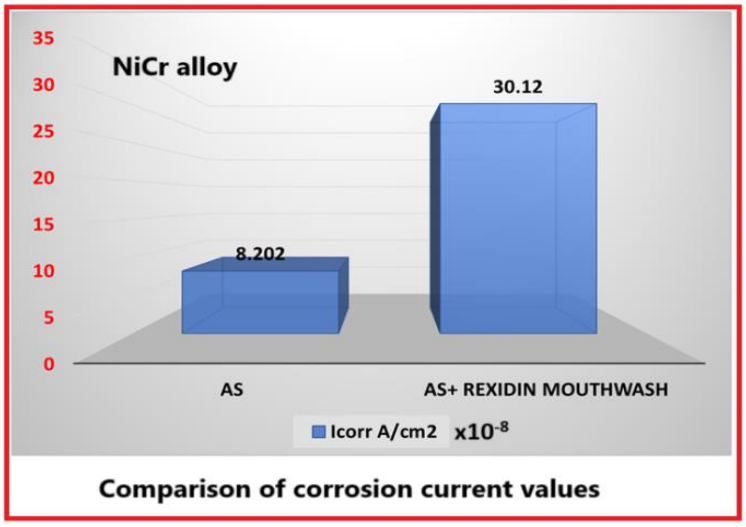


Figure 8. Comparison of corrosion current values of Ni-Cr alloy

Ni-Cr alloy in AS system

When a Ni-Cr alloy is immersed in an artificial saliva environment, the LPR value is recorded at 552959 Ohmcm², whereas the corrosion current is noted to be 8.202×10^{-8} A/cm².

Ni-Cr alloyin AS + Rexidin SRS mouthwashsystem

The incorporation of 10 ml of Rexidin SRS mouthwash into the artificial saliva system leads to a decrease in the LPR value to 149840 Ohmcm², whereas the corrosion current increases to 30.12×10^{-8} A/cm². This indicates that the inclusion of Rexidin SRS mouthwash reduces the corrosion resistance of Ni-Cr alloy within the artificial saliva environment.

Corrosion potential

In the presence of Rexidin SRS mouthwash, the shift in corrosion potential is nearly 50 mV. This represents a mixed type shift. Both anodic and cathodic reactions are accelerated to a similar degree.

The various corrosion parameters derived from the polarization study are depicted and contrasted in Figures 6-8.

Implication

The use of Rexidin SRS mouthwash diminishes the corrosion resistance of Ni-Cr alloy when exposed to artificial saliva. Consequently, it is advisable for individuals with orthodontic wires made of Ni-Cr alloy to avoid using Rexidin SRS mouthwash.

Contact angle measurements

Contact angle measurements have been employed in research related to corrosion inhibition [21,22]. A rise in corrosion protection is associated with an increased contact angle. The degree of hydrophobicity is heightened. The water-repelling property is significant. Wettability is reduced.

On the other hand, a reduction in corrosion protection leads to the contrary effect. Taking these observations into account and analyzing Figure 9, it can be inferred that the corrosion resistance of Ni-Cr alloy in artificial saliva decreases when exposed to Rexidin SRS mouthwash. This suggests that individuals with orthodontic wires composed of Ni-Cr alloy ought to refrain from using Rexidin SRS mouthwash.

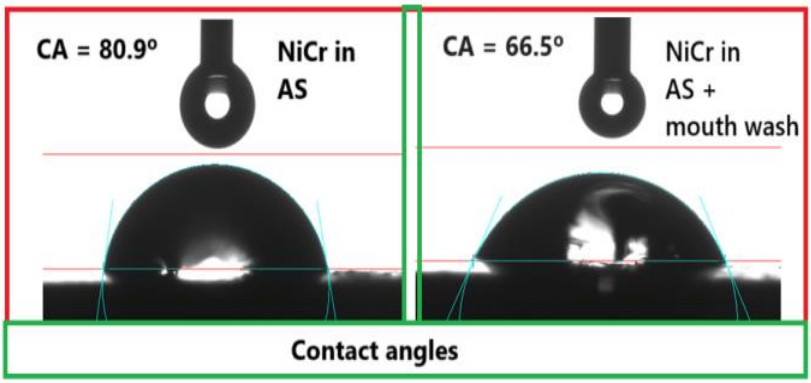


Figure 9.Contact angles of various surfaces

Analysis of SEM images

The examination of SEM images has been utilized in research related to corrosion inhibition [23,24]. As the effectiveness of corrosion protection increases, the surface generally appears smoother. In contrast, when corrosion protection decreases, the surface tends to become rougher, and pits may be visible on the corroded surface.

Taking into account these observations and analyzing Figure 10, it can be inferred that the corrosion resistance of Ni-Cr alloy in artificial saliva diminishes when exposed to Rexidin SRS mouthwash. This suggests that individuals with orthodontic wires composed of Ni-Cr alloy should refrain from using Rexidin SRS mouthwash.

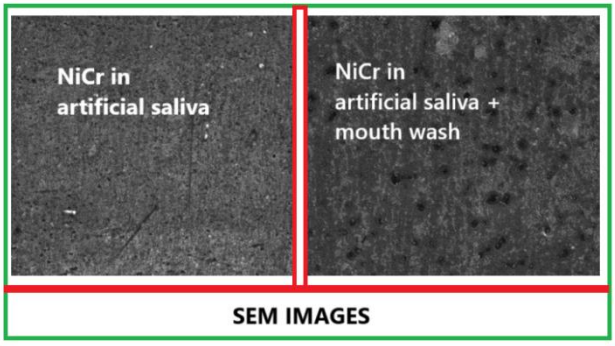


Figure 10.SEM images of various surfaces

Taking into account these observations and analyzing Figure 10, it can be inferred that the

corrosion resistance of Ni-Cr alloy in artificial saliva diminishes when exposed to Rexidin SRS mouthwash. This suggests that individuals with orthodontic wires composed of Ni-Cr alloy should refrain from using Rexidin SRS mouthwash.

4. CONCLUSION

The application of Rexidin SRS mouthwash reduces the corrosion resistance of Ni-Cr alloy when subjected to artificial saliva. Therefore, it is recommended that individuals with orthodontic wires composed of Ni-Cr alloy refrain from using Rexidin SRS mouthwash.

Acknowledgement

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IZVOD

UTICAJ TEČNOSTI ZA ISPIRANJE USTA REXIDIN SRS NA KOROZIVNE KARAKTERISTIKE Ni-Cr ORTODONTSKE ŽICE POTOPLJENE U VEŠTAČKU PLJUVAČKU

Zubi koji su pravilno poravnati smatraju se atraktivnim; međutim, neke osobe imaju prirodno nepravilan poravnanje zuba. Da bi rešili ovaj problem, ortodonti koriste žice. Nakon postavljanja žica, pacijenti konzumiraju raznovrsnu hranu, piju napitke i uzimaju tablete oralno, što može predstavljati rizik za žice. Pored toga, žice su podložne koroziji kada dođu u kontakt sa pljuvačkom. Ova studija je ispitala otpornost na koroziju ortodontskih žica napravljenih od termoaktivne legure u veštačkoj pljuvački, sa i bez uključivanja tečnosti za ispiranje usta Rexidin SRS, putem analize polarizacije. Karakteristike korozije Ni-Cr legure su procenjene za dva sistema: sistem veštačke pljuvačke i sistem veštačke pljuvačke u kombinaciji sa Rexidin SRS sistemom za ispiranje usta. Eksperiment je obuhvatio merenje linearne otpornosti na polarizaciju (LPR) i vrednosti struje korozije. Studija je dala sledeće rezultate. Rangiranje otpornosti na koroziju ortodontske žice od legure Ni-Cr je sledeće: Veštačka pljuvačka > Veštačka pljuvačka u kombinaciji sa tečnosti za ispiranje usta Rexidin SRS. Ovo ukazuje da osobe koje koriste Ni-Cr ortodontsku žicu treba da izbegavaju upotrebu tečnosti za ispiranje usta Rexidin SRS.

Ključne reči: *Otpornost na koroziju, ortodontska žica, Ni-Cr, veštačka pljuvačka, tečnost za ispiranje usta Rexidin SRS.*

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