

INFLUENCE OF CHLORHEXIDINE MOUTHWASHES ON CORROSION RESISTANCE OF NI-CR DENTAL CASTING ALLOYS

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Abstract

The aim of the present study was to compare the corrosion behavior of the Ni-Cr alloys used for crown and bridge casting in three mouthwashes, in relation to a reference solution, namely Fusayama Meyer saliva, in order to assess the influence of these products on the corrosion resistance of the Ni-Cr dental alloys.

The Three materials analyzed were Ni-Cr dental alloys: Kera NC®, Realloy N® and 4 all®, which were tested in three mouthwashes: Hexa®, Hexadyle® and Coxydil® as well as in Fusayama-Meyer artificial saliva. The corrosion behavior study showed that in Hexa® mouthwash the 4 all® alloy was the least resistance to corrosion, in Fusayama-Meyer artificial saliva tended to be more corrosive for Kera NC® alloy, in Coxydil® mouthwash exhibited the highest corrosion resistance for Kera NC®, and 4 all® alloys, in Coxydil® and Hexadyle® mouthwashes exhibited the highest corrosion resistance for Realloy N® alloy.

The results obtained in the present study will enable us to provide attending practitioners with advice concerning mouthwash to recommended, depending on the treatment phase and the alloy used. So we can advise Coxydil® mouthwash to patients treated with 4 all® and Kera NC® alloys, Coxydil® or Hexadyle® mouthwashes for the patients treated with Realloy N® alloy.

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Introduction

Metals and alloys have many uses in dentistry. The most commonly used base metal alloys in dentistry are nickel-chromium alloy, which are commonly used for crown and bridge casting. The most important factors that affect the choice of dental metallic alloys are the body acceptability for these alloys, or the so-called biocompatibility^{1,2}.

This means that the tissue of the patient that comes into contact with the materials does not suffer from any toxic, irritating, inflammatory, allergic, mutagenic, or carcinogenetic action^{3,4}.

The biocompatibility of dental alloys is primarily related to their corrosion behavior⁵. A number of studies have demonstrated that metals ions can be released from metallic materials as the results of corrosion⁶⁻¹².

Since the corrosion products of dental alloys contain metal ions and may be the reason for allergic and some other diseases^{13,14}.

During crown and bridge treatment and the Ni-Cr alloy used, practitioners recommend that their patients use mouthwashes for oral hygiene. To our knowledge, no studies have yet been carried out to assess the influence of chlorhexidine mouthwashes on the corrosion behavior of Ni-Cr alloys,

The purpose of the present study was to compare the corrosion behavior of the Ni –Cr alloys used for crown and bridge casting in three mouthwashes, in relation to a reference solution, namely Fusayama Meyer saliva, in order to assess the influence of these products on the corrosion resistance of the Ni –Cr dental alloys.

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Materials and methods

The origin and composition of the Ni–Cr dental alloys studied are shown in table 1. Kera NC®, Realloy N® and 4 all® alloys were used as test materials in this study. The three samples were selected from metal used for crown and bridge casting. Each specimen of each type of material was cut in the form of a cylinder of diameter 7 and 15 mm length, and then embedded with epoxy resin leaving a working area of 0.38 cm² for each specimen. The working electrodes were mechanically polished with abrasive paper of different grades (400-1000-1500), washed in distilled water and then dried with ethanol before corrosion test.

Material	Composition (wt%)	Supplier
Kera NC®	Ni: 66 % , Cr: 22.5 %, Mo: 9%, Mn: 0.5%, Si:0.9%, Fe: < 0.9%, Nb: 0.5%, C: < 0.1%	EisenbacherDentalwaren Ed Gmbh, Germany
Realloy N®	Ni: Bal , Cr: 24%, Mo: 10%, Si:1.7%, Fe:1.4% Total all others < 1.0%	Realloy e. k Karnaksweg35/b, DE-58636 Iserlohn, Germany
4 all®	Ni: 61.4 % , Cr: 25.7 %, Mo: 11%, Si:1.5%, Al, Mn ,C: < 1.0%	Ivoclar,Vivadent, Germany

Table 1. Origin and Composition of materials.

Test solutions

The reference electrolyte was Fusayama-Meyer artificial saliva, which closely resembles natural saliva¹⁵⁻¹⁷. The pH was measured with a glass electrode (Ph meter HANNA Instrument, France). The pH of this reference saliva measured was 5.3. The second test solution used was Hexa® ready to use mouthwash (Arak pharma, Syria). The pH measured was 4.6. The third test solution used was Hexadyle® ready to use mouthwash (Shaba pharma. Yemen). The pH measured was 6.9. The last test solution used was Coxydil® ready to use mouthwash (Shaphaco, Yemen). The pH measured was 7.1. The composition of Fusayama-Meyer artificial saliva and mouthwashes are shown in table 2.

Solution	Composition
Fusayama-Meyer Artificial saliva	KCl (0,4 g/l), NaCl (0,4 g/l), CaCl ₂ .2H ₂ O (0,906 g/l), NaH ₂ PO ₄ .2H ₂ O (0,690 g/l), Na ₂ S. 9H ₂ O (0,005 g/l), Urea (1 g/l)
Hexa®	Chlorhexidine gloconate 0.2%,
Hexadyle®	Chlorhexidine gloconate B.P. 0.2% w/v, Sorbitol, Propylene glycol, Methyl & propyl parabens, peppermint flafour, Methanol, Ethanol, Color & Water.
Coxydil®	Chlorhexidine gloconate B.P. 0.2% w/v

Table 2. Composition of Fusayama-Meyer artificial saliva and mouthwashes.

Electrochemical measurements

The electrochemical measurements were carried out at room temperature, a potentiostat (PGZ 100 France radiometer analytical S.A) was used to perform the electrochemical measurements. A saturated calomel electrode (SCE) was used as reference electrode, platinum was used as counter-electrode and Ni-Cr samples as working electrode, controlled by a personal computer with dedicated software (Volta Master 4). The polarization curves were plotted in the potential range of -1000 mV/SCE to +1000 mV/SCE at scanning rate of 0.2 mV/s.

The Corrosion parameters, including corrosion potential (E_{corr}), corrosion current density (I_{corr}) and polarization resistance (R_p). The corrosion potential values are given in mV/SCE, polarization resistance values are given in kΩcm². Corrosion current density values are given in μA cm⁻². The experiments were performed two times for each Ni–Cr dental alloys in each test solution. The E_{corr} , I_{corr} , and R_p values are the mean of two experiments with a maximum error of 10-15%.

Surface analysis

Two of the alloys, of Kera NC® and 4 all® were observed using scanning electron microscopy (SEM) (Philips, Quanta 200 X. TM-© Fei Company). The samples were subjected to immersion for 10 days in two different media: Fusayama-Meyer artificial saliva and hexa® ready to use mouthwash.

Results

The polarization curve of Kera NC® (Fig.1) and values reported in Table 3 indicate that this material exhibited the highest corrosion resistance in Coxydil® and Hexadyle® mouthwashes. In Hexa® mouthwash, the polarization resistance value was high compare with that of reference solution.

Solution	E_{corr} (mV)	I_{corr} (μA cm ⁻²)	R_p (kΩcm ²)
Fusayama-Meyer artificial saliva	- 331.2±14.9	8.63±0.34	8.16±0.27
Hexa®	- 395±15.9	4.76±0.28	14.91±0.06
Hexadyle®	- 452.95±12.95	1.63±0.03	38.13±1.32
Coxydil®	- 389.5±0	1.29±0.12	58.38±0.16

Table 3. Corrosion parameters of Kera NC® in different media.

In Fusayama-Meyer artificial saliva the corrosion current density was very high and the

polarization resistance value was very low. Kera NC®, thus presented good corrosion resistance in Coxydil® and Hexadyle® mouthwashes.

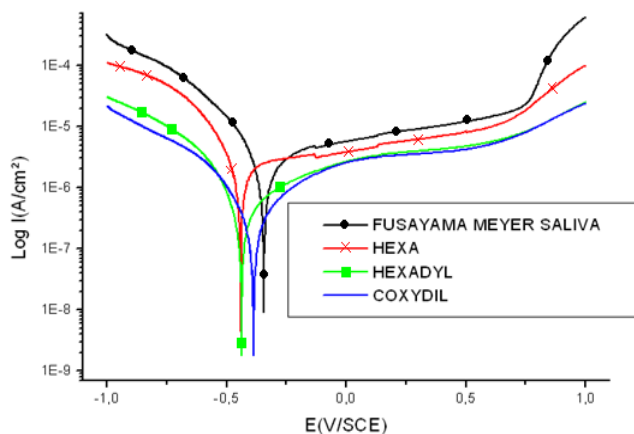


Figure 1. Polarization curves for Kera NC® in different media.

The polarization curve of Realloy N® (Fig. 2) and results presented in Table 4 indicate that Realloy N® exhibited the least corrosion resistance in Fusayama-Meyer artificial saliva. In Coxydil® mouthwash the corrosion current density was very low and the polarization resistances value was very high.

In Hexadyle® mouthwash the corrosion current density was low and the polarization resistance value was high, Realloy N®, thus presented good corrosion resistance in Coxydil® and Hexadyle® mouthwashes compared with Fusayama-Meyer artificial saliva.

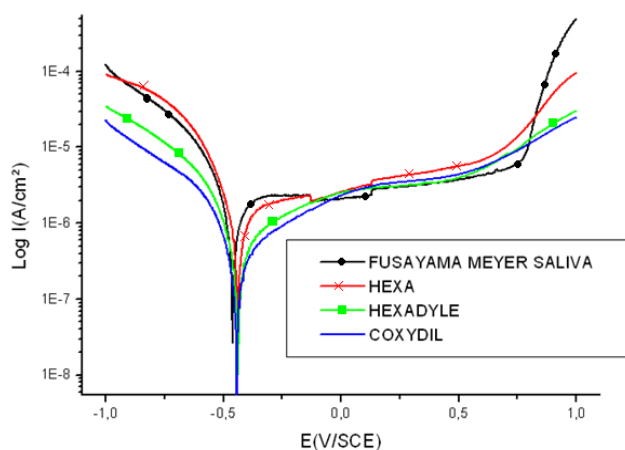


Figure 2. Polarization curves for Realloy N® in different media.

Solution	E_{corr} (mV)	I_{corr} ($\mu A cm^{-2}$)	R_p ($k\Omega cm^2$)
Fusayama-Meyer artificial saliva	-478.9±15.1	7.76±1.3	9.28±1.28
Hexa®	-415.3±25.6	4.45±0.15	13.64±0.3
Hexadyle®	-455.25±14.75	2.72±0.37	36.6±4
Coxydil®	-415±5.45	1.11±0.09	49.20±3.77

Table 4. Corrosion parameters of Realloy N® in different media.

The results obtained for 4 all® alloy (Fig. 3 and table 5) were different from those obtained with Kera NC® and Realloy N® especially in Fusayama-Meyer artificial saliva and Hexa® mouthwash.

As summarized in Table 5 the polarization resistance obtained for 4 all® alloy in Fusayama-Meyer artificial saliva was high compared with that of Kera NC® and Realloy N®.

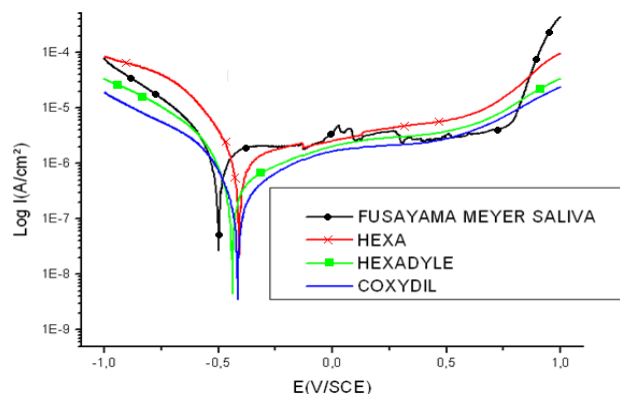


Figure 3. Polarization curves for 4 all® in different media.

Solution	E_{corr} (mV)	I_{corr} ($\mu A cm^{-2}$)	R_p ($k\Omega cm^2$)
Fusayama-Meyer artificial saliva	-490.9±11	5.54±0.48	12.14±1.24
Hexa®	-451.5±6.8	7.10±0.08	8.72±0.18
Hexadyle®	-436±5.6	1.97±0.10	43.34±0.87
Coxydil®	-445.6±28.3	1.06±0.09	63.19±5.34

Table 5. Corrosion parameters of 4 all® in different media.

On the other hand, in Hexa® mouthwash this material was the least resistance to corrosion compared with that of Kera NC® and Realloy N®. In Coxydil® mouthwash the polarization resistance value was very high and the Corrosion current density was very low.

Surface analysis

The scanning electron microscopy of the Kera NC® and 4 all® after immersion in Fusayama-Meyer artificial saliva and Hexa® mouthwash for 10 days were studied. In Fusayama-Meyer artificial saliva, the

micrographs have shown that pitting corrosion on the surface of Kera NC® (Fig. 4), while for 4 all® (Fig. 5) there is a change in color of the alloy surface which may be due to immersion for long time.

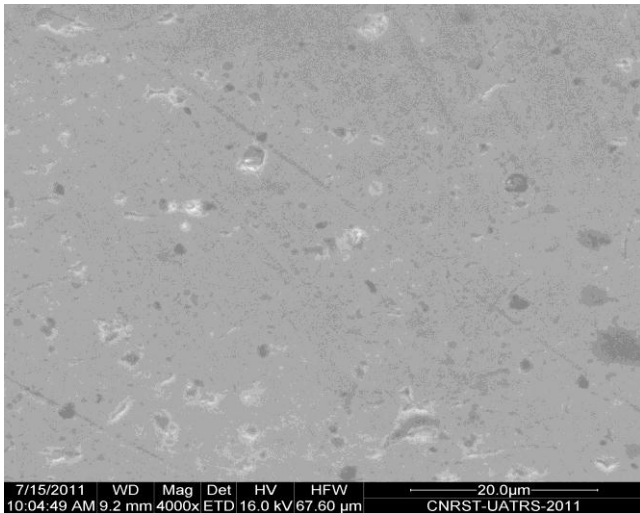


Figure 4. The scanning electron microscopy of Kera NC® in Fusayama-Meyer saliva.

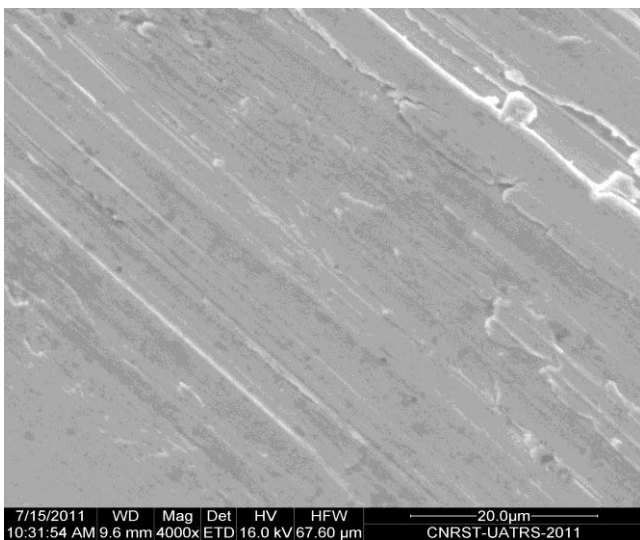


Figure 5. The scanning electron microscopy of 4 all® in Fusayama-Meyer saliva.

In Hexa® mouthwash, the micrographs have shown that weak pitting corrosion on the surface of 4 all® (Fig. 6), while for Kera NC® (Fig. 7) there is no corrosion but there is a general change in the surface of the alloy.

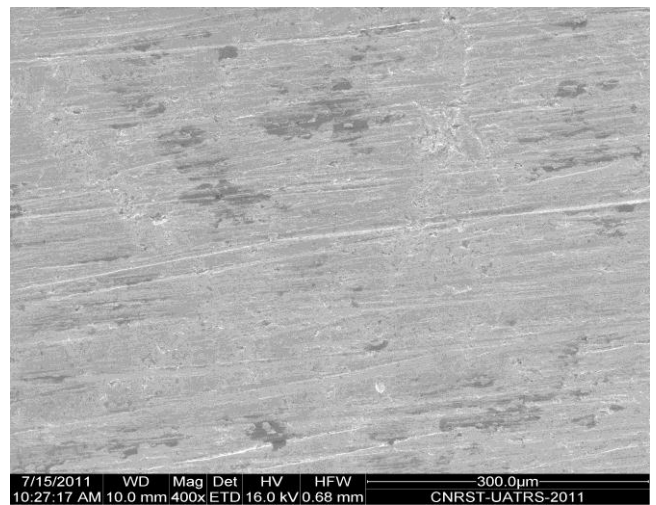


Figure 6. The scanning electron microscopy of 4 all® in Hexa® mouthwash.

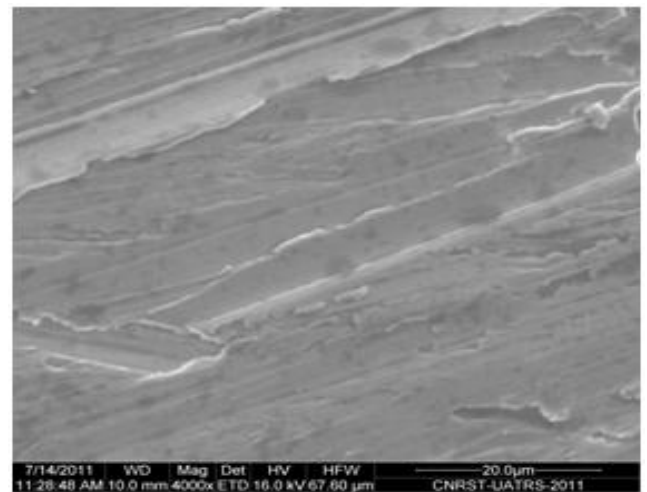


Figure 7. The scanning electron microscopy of Kera NC® in Hexa® mouthwash.

Discussion

From the results presented in Tables 3,4 and 5, in Fusayama-Meyer artificial saliva the polarization resistance of 4 all® was high compared with that of Kera NC® and Realloy N®. On the other hand, the Kera NC® was the least resistance to corrosion in Fusayama-Meyer artificial saliva. Thus, in Fusayama-Meyer artificial saliva the corrosion resistance of the three Ni-Cr dental alloys are in the following order: 4 all® > Realloy N® > Kera NC®.

In the present study shows that, the presence of high concentration of chromium (Cr: 25,7 % in 4 all®) shows the best corrosion resistance in artificial saliva. This result confirmed the result of Christopher et al¹⁸, who

showed that, the Ni –Cr alloy containing a higher level of Cr (25 wt.%) showed superior corrosion resistance in artificial saliva. On the other hand, the present study shows that, the low percentage of molybdenum (Mo: 9% in Kera NC®) shows the least corrosion resistance in artificial saliva. This result confirmed the result of Toumelin-Chemela¹⁹ who showed that, the molybdenum in lesser extent increase the tendency to passivation of Ni-Cr. Thus, chromium as chromium oxide (Cr₂O₃) and molybdenum as molybdenum oxide (Mo₃) provide the initial stability to prevent dissolution of metal ions and thus provide resistance to corrosion²⁰.

In Hexa® mouthwash was shown to be the most aggressive of the tested mouthwash for 4 all® alloy. The polarization resistance value of 4 all® was low and the corrosion current density value was high.

In Hexa® mouthwash the corrosion resistances of the three Ni-Cr dental alloys are in the following order: Kera NC® > Realloy N® > 4 all®. In Hexadyle® mouthwash the polarization resistance value obtained for 4 all® alloy was high compared with that of Kera NC® and Realloy N® alloys.

In Hexadyle® mouthwash the corrosion resistances of the three Ni-Cr dental alloys are in the following order: 4 all® > Kera NC® > Realloy N®. In Coxydil® mouthwash the polarization resistance values obtained for 4 all®, Kera NC® and Realloy N® were very high compared with that of Hexa® mouthwash and Fusayama-Meyer artificial saliva. Coxydil® mouthwash shows the best corrosion resistance for 4 all®, Kera NC® and Realloy N® alloys. The corrosion resistances of the three Ni-Cr dental alloys in three mouthwashes are in the following order: Coxydil® > Hexadyle® > Hexa®.

Thus, 4 all® alloy exhibited the highest corrosion resistance in Fusayama-Meyer artificial saliva, Hexadyle® and Coxydil® mouthwashes compared with that of Kera NC® and Realloy N®. On the other hand, Kera NC® alloy exhibited high corrosion resistance in Hexa® mouthwash compared with that of Realloy N® and 4 all® alloys. In the present study, shows that, the concentration of pH in mouthwash effect on the corrosion resistance for Ni-Cr dental alloys (pH 4.6 in Hexa® mouthwash shows the least corrosion resistance for Ni-Cr alloys and pH 7.1 in Coxydil® shows the highest corrosion resistance for Ni-Cr alloys). Study of Huang²¹ the

effect of chemical composition on the corrosion behavior of Ni-Cr-Mo dental casting alloys, revealed that, a percentage from 12 to 35 from Cr and 8 to 12 from Mo immunized against pitting corrosion. Bennani et al.²² showed that, the composition and mode of the alloys preparation affect on the electrochemical behavior of Ni- Cr alloys.

Khamis and Seddik²³ also Ozdemir and Arican²⁴ compared the electrochemical behavior of Ni- Cr and Co-Cr in the mouth , they found a sensitivity of Ni-Cr corrosion pitting in chloride solutions, while the Co-Cr has a more noble behavior. M.A. Ameer et al²⁵ electrochemical behavior of non-precious dental alloys in bleaching agents showed that, the effect of carbamide peroxide on the corrosion is less than that of hydrogen peroxide

Conclusions

The results of present study should help attending practitioners decide which mouthwash to prescribe for their patients, depending on the crown and bridge treatment and the Ni-Cr alloy used. In the present study, it has been shown that the corrosion behavior of Kera NC® alloy was the least resistance to corrosion in Fusayama-Meyer artificial saliva and corrosion behavior of 4 all® alloy exhibited the highest corrosion in Hexa® mouthwash.

On the basis of the results obtained, our advise would be to recommend Coxydil® mouthwash to patients treated with 4 all® and Kera NC® alloys, Coxydil® or Hexadyle® mouthwashes for the patients treated with Realloy N® alloy.

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Declaration of Interest

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