Short Communication

Microbial Adherence to a Nonprecious Alloy After Plasma Nitriding Process

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Purpose: To investigate the microbial adherence to the surfaces of a nonprecious metal alloy after plasma nitriding. ***Materials and Methods:*** The plasma-nitriding process was performed to the surfaces of metals prepared from a nickel-chromium alloy. The microorganisms were labeled with technetium-99m. After the labeling procedure, 60 metal disks were treated with a microorganism for each use. ***Results:*** The results revealed that the amount of adherence of all microorganisms on surfaces was changed by plasma-nitriding process; adherence decreased substantially ($P < .05$) and the differences in plasma nitriding time were not significant ($P > .05$) ***Conclusion:*** With the plasma-nitriding process, the surface properties of nonprecious metal alloys can be changed, leading to decreased microbial adherence. *Int J Prosthodont 2006;19:202–204.*

Surface characteristics are important factors in fostering the accumulation of dental plaque on smooth hard surfaces.[1] With progressions in surface technology, the surface characteristics of metals can be changed. Today, as a modern surface-hardening technique, plasma nitriding is used to enhance the surface properties of materials.[2] The aim of the present study was to determine the microbial adhesion to a nonprecious alloy after plasma nitriding by using technetium-99m (^{99m}Tc) radiolabeled microorganisms.

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Materials and Methods

Sixty nickel-chromium (Ni-Cr) metal (Wirolloy, Bego Bremer Goldschllagerie Wild Herbst Gmbh & Co) disks were fabricated according to manufacturers' instructions (thickness: 3 mm, diameter: 10 mm). The plasma-nitriding process was carried out in a laboratory-type ion-nitriding unit. The voltage and current density ranges were 400 to 800 V and 0.025 to 0.040 mA/mm^2, respectively, depending upon the gas composition and process temperature. A total gas pressure of 2.1 mbar was kept constant throughout the study. The process temperature, times, and gas composition were 400ºC; 6 hours, 8 hours, and 10 hours; and 95% nitrogen (N_2) + 5% hydrogen (H_2), respectively. All surfaces except for one flat face of each specimen were plasma nitrided. The one flat face of the 30 samples served as a control group (no treatment). After treatment, the specimens were allowed to cool in the vacuum chamber. Following this procedure, matte gray metal surfaces were repolished with conventional polishing methods. The microorganisms (*Escherichia coli* [American Type Culture Collection (ATCC) 25922], *Streptococcus mutans* [ATCC

Table 1 Percentage of Adherence of Microorganisms, as Viewed by Radiolabeling with ^{99m}Tc, to a Ni-Cr (Wirolloy) Alloy Before and After Plasma Nitriding

Surface	% Adhesion of *S mutans*	% Adhesion of *C albicans*	% Adhesion of *E coli*	*P* (one-way ANOVA)	Dunnett C
Control group (no treatment)	7.02 ± 2.18	8.80 ± 8.24	0.96 ± 0.49	.000	†,‡
6 hours	4.82 ± 1.98	1.45 ± 0.99	0.60 ± 0.29	.000	*,†,‡
8 hours	4.67 ± 1.17	1.42 ± 0.38	0.59 ± 0.16	.000	*,†,‡
10 hours	4.62 ± 1.16	1.44 ± 0.37	0.59 ± 0.15	.000	*,†,‡

*Significant difference between *S mutans* and *C albicans;* †Significant difference between *S mutans* and *E coli*; ‡Significant difference between *C albicans* and *E coli*.

10499], and *Candida albicans* [ATCC 90028]) were labeled with ^{99m}Tc, and their radiolabeling yields were calculated.[3] After the labeling procedure, the metal disks were treated with a microorganism for each use with the method described previously by Sonugelen et al.[3] The experiments were performed on all sides of all metal samples for each ^{99m}Tc-labeled microorganism.[4] This procedure was repeated 3 times for each experiment.

The surface roughness of each sample was measured with a surface roughness machine (SJ-201, Mitutoyo). Vickers microhardness tests were performed using a digital microhardness tester (Teskon HSV-1000). The obtained data were statistically evaluated with the *t* test, repeated-measures analysis of variance (ANOVA), and one-way ANOVA ($\alpha = .05$) as a Dunnett C test (Post Hoc method) was performed to determine the differences in the adherences of *S mutans, C albicans,* and *E coli* on metal surfaces.

Results

The mean values for surface roughness of the metal samples before and after the plasma-nitriding process were measured as 1.19 ± 0.39 μm (R_a) for the control group (no treatment), 0.76 ± 0.21 μm (R_a) for the 6-hour group, 0.72 ± 0.17 μm (R_a) for the 8-hour group, and 0.76 ± 0.19 μm (R_a) for the 10-hour group. The microhardness values of the metal samples before and after plasma nitriding were measured as 262 ± 2.51 Hv for the control group, 381.0 ± 2.05 Hv for the 6-hour group, 409.27 ± 6.41 Hv for the 8-hour group, and 426.0 ± 3.57 Hv for the 10-hour group. Cross-sectional scanning electron microscopic images of the plasma-nitrided sample surfaces (6-hour group) showed that the surface typically consisted of a compound layer and a diffusion zone (Fig 1). Adherence values of three microorganisms on the metal samples before plasma nitriding were (mean ± SD) 8.80% ± 8.24% for *C albicans*, 0.96% ± 0.49% for *E coli*, and 7.02% ± 2.18% for *S mutans*; these values decreased after plasma nitriding for the 6-hour, 8-hour, and 10-hour groups (Table 1). The results revealed that the amount of adherence of all microorganisms on surfaces treated with plasma nitriding decreased substantially ($P < .05$); the differences in plasma-nitriding time were not significant ($P > .05$) (Table 1).

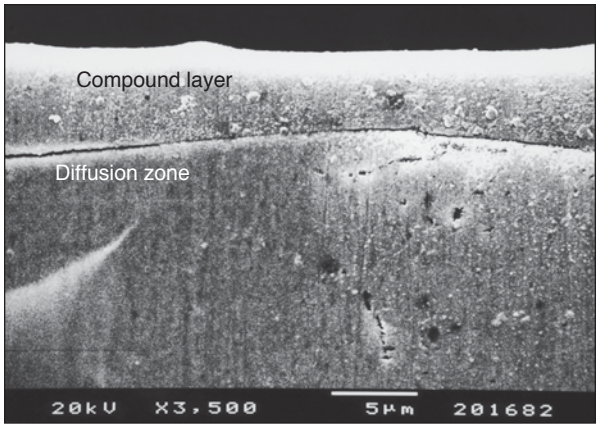

Fig 1 Cross-sectional scanning electron micrograph of a (6-hour) plasma-nitrided metal sample.

Discussion

As a modern surface-hardening technique, plasma nitriding is used in industries concerned with iron, steel, titanium, and Ni-Cr alloy products. To the authors' knowledge, there is limited literature concerning low-temperature (400°C) nickel-base alloy nitriding. Ni-Cr alloys, depending on the plasma reactivity, consist of 2 or 3 distinct layers.[2] In the present study, 2 layers, consisting of a compound one and a second diffusion zone, were determined.

The adherence of *E coli*, *S mutans*, and *C albicans* to the surfaces of the Ni-Cr alloy after plasma nitriding process was investigated in the present study. As a novel surface-hardening technique, the plasma-nitriding process increases the surface hardness of metal samples while decreasing their surface roughness. While statistical evidence is not provided in the present study, other studies showed that rough surfaces increased bacterial adhesion; however, there was no direct correlation between bacterial adhesion and surface irregularities.[5] The present study appears to agree with others' findings. However, it must be acknowledged that since both surface hardness and roughness were changed at the same time, definitive conclusions that explain changes in bacterial adherence are precluded. Furthermore, comprehensive comparisons with other alloys with different physical properties in the context of modifications of surface roughness are necessary before any significant conclusions can be drawn.

Conclusion

With the plasma-nitriding process, the surface properties of nonprecious metal alloys can be changed, leading to decreased microbial adherence.

References

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Literature Abstract

Implant therapy in partially edentulous, periodontally compromised patients: A review

The aim of this study was to determine the success rate of implant therapy in periodontally compromised, partially dentate patients through a literature review evaluation. Thousands of articles were screened in the MEDLINE system with selection criteria to include controlled clinical trials and uncontrolled clinical studies with at least 5 years follow-up. Specific criteria included: *(1)* implant treatment, *(2)* involvement of periodontally compromised patients, *(3)* partially edentulous patients, *(4)* clinical trials with at least a 5-year follow-up period, *(5)* outcome variables to include implant success rate or bone loss. After initial screening of 877 papers, only 4 articles were selected that met the above criteria regarding implant success in periodontal patients. The following articles include Mengel et al (2001), Leonhardt et al (2002), Hardt et al (2002), and Karoussis et al (2003). Conclusions from these clinical studies are that implants placed in partially dentate patients with periodontal involvement have a high risk of colonization from putative periodontal pathogens as opposed to fully edentulous patients. Implants should not be placed on patients with existing local inflammation or inadequate oral hygiene. Smokers increase their risk for having implant failure by almost 2.5 times. Comparatively, the survival rates between periodontally involved and non-perio patients are 90.5% and 96.5% respectively. Success rate is 52.4% for perio patients and 79.1% for non-perio patients. The most critical issue is standardization of criteria for the determination of which patients constitute "periodontally involved patients" from a preventive and research standpoint.

Van der Weijden GA, van Bemmel KM, Renvert S. *J Clin Periodontol* 2005;32:506–511. **References:** 29. **Reprints:** Fridus Van der Weijden, Department of Periodontology, Academic Center for Dentistry Amsterdam, Louwesweg 1, 1066 EA Amsterdam, The Netherlands. Email: ga.vd.weijden@acta.nl—*Esquivel-Upshaw, San Antonio, TX*