MEASUREMENT OF ^{99m}Tc-MDP ADSORPTION OF SOME DENTAL ALLOYS

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SUMMARY: Test samples of five different dental alloys were prepared in discs 10 mm in diameter and 1.5 mm thick. Their surfaces were sandblasted, ground with sand paper, polished and electrolyzed in succession. 10 samples of each alloy in each surface finishing were prepared Surface roughness of each disc was determined by the use of a profilometre. The adsorption of the surfaces was measured by ^{99m}Tc-MDP both before and after 2 h of exposure to oral environment. The results indicated that the discs sandblasted and electrolyzed had the maximum and those polished the minimum surface roughness. The adsorption showed variation according to surface roughness and to the alloy type prior to exposure to oral environment. Alloy samples with different surface roughness placed in the oral cavity exhibited similar adhesive properties.

Key Words: Dental alloys, Surface roughness, ^{99m}Tc-MDP adsorption, Oral environment.

INTRODUCTION

The acquired pellicle and plaque formed on dental surfaces have been widely studied and well characterized (1,3,10,14,15,18). These biofilms accumulate on all material surfaces placed in the oral cavity for restorative purposes as well (4,7,13). Investigations have shown that in principle the nature of these films whether on dental or prosthetic material surfaces is the same (10). Although increased accumulation of plaque was observed with increased surface roughness in many investigations (5,6,11,12). Clayton and Green (2) did not find any correlation. Sanding and Endert (16), measuring the adsorption of ^{99m}Tc-MDP on different alloy surfaces in vitro, concluded that the adhesive properties depended on the type of material used rather than on the surface structure. Jendresen and Glantz (8/) investigated the in vivo adhesiveness of the normal tooth surface by measuring the critical surface tension of wetting and found that it was the same over a wide range of ages in both sexes. When various polished dental materials of different critical surface tension were placed in the oral cavity for 2 h, they exhibited the same clinical adhesiveness (9). Because of the controversial views on the clinical adhesiveness of dental materials this subject was re-investigated in the present study, using dental alloys of different surface finishings.

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Table 1: Dental alloys used in this study.

Name	Alloy type	Composition	Company
Wiroscast	Co - Cr	35% Co, 30% Cr, 29% Fe, 3% Mo, 0.35% Si, Mn, C	Bego, Bremen, F.R.G.
Remanium GM 380	Co - Cr	64.5% Co, 29%Cr, 4.5% Mo, 0.3% Mn, 0.5% Si, 0.6% C	Dentaurum, Pforzheim, F.R.G
Wirolloy	Ni - Cr	63% Ni, 23% Cr, 3% Mo, 0.07 %Si, Mn, Fe, C	Bego, Bremen, F.R.G
Remanium G soft	Ni - Cr	-	Dentaurum, Pforzheim, F.R.G.
Argenco No. 75	Au-Ag-Pd	56% Au, 3.6% Pd, 26% Ag, Cu	Somadenta A.S., Istanbul, Turkey

MATERIALS AND METHODS

1. Preparation of samples:

Five different dental alloys (2Co-Cr, 2Ni-Cr and 1 Au-Ag-Pd) were used in this study. The compositions of all alloys are summarized in Table 1 except for Remanium G soft, which is not given by the manufacturer. A Total of 170 samples (40 samples in each of Co-Cr alloys and 30 samples in each of the other alloys) having a diameter of 1 cm and a thickness of 1.5 mm were prepared. A hole was drilled in each disc close to the edge. Preheating, heating and casting were done according to the instructions of the manufactures.

2. Surface Finishing:

a) Sandblasting: Ten samples from each Co-Cr and Ni-Cr alloys were first sandblasted with a coarse grain sand (Alox 250, Bego, F.R.G.) for 30 sec and then with a fine grain sand (Ivoclar, 125 μm, Ivoclar AG, Liechtenstein) for 15 sec in a sandblaster Ivoclar AG, Liechtenstein). Argenco No. 75 was sandblasted only with fine grain sand.

b) Sand paper ground: Ten samples from each five alloys were ground with 240, 320, 400 and 600 grit SIC in roll grinder (Handimet II, Buehler Ltd., U.S.A.) in succession. Between each grit the sample was turned 90° and ground until the tracts belonging to the previous grinding disappeared. Each sample was examined under a microscope (Nikon, Nippon Kogaku K.K., Japan).

c) Polishing: Ten samples from each of five alloys, previously ground according to the above method, were polished for 10 min using an abrasive material (Finischpaste, gelb, für Hochglanz Cor-Cr und Edelmetall, Dentaurum, F.R.G.) and a low speed polished (Buehler Ltd., U.S.A.). The direction of polishing was changed every 2.5 min. The disc surfaces were examined under the microscope and polishing continued if necessary.

d) Electrolysis: Ten samples of each of Co-Cr alloys (Wirocast and Remanium GM 380) were first sandblasted and then subjected to electrolysis for 5 min in a home-made electrolysis chamber using a special electrolyte solution (Solution speciale Chrome-Cobalt-Molybdene, Howmedica Inc., U.S.A). A copper plate was used as the cathode. The sample discs were connected to the anode. The solution temperature was 30-40°C (mean: 35) and the current was 1 Amp. The electrolyte was changed after five samples. After electrolysis samples were washed under running water.

3. Measurement of Surface Roughness:

The surface roughness of all the prepared samples were measured with a profilometre (Talysurt 6, Rank Taylor-Habson Ltd., England). Measurements were made at four different spots randomly selected in each sample. Care was taken to change the orientation of the sample between each measurement. Both the mean (R_a) and maximum (R_{max}) roughness values were obtained together with the profile plot of roughness.

Table 2: Surface roughness (R_a) of dental alloys with different surface finishings (mean ±SD in μm).

Name of the alloy	Sandblasted	Surface Finishing Sand paper ground	Polished	Electrolyzed
Wirocast	1.187±0.090	0.210±0.064	0.069±0.026	1.02±0.32
Remanium GM 380	1.000±0.506	0.224±0.048	0.058±0.055	1.51±0.49
Wirolloy	1.416±0.202	0.209±0.050	0.075±0.035	
Remanium G soft	1.241±0.218	0.243±0.099	0.119±0.043	
Argenco No 75	1.302±1.404	0.534±0.082	0.043±0.019	

Statistically significant difference ($p<0.01$ - $p<0.0001$) between surface finishings within each alloy.

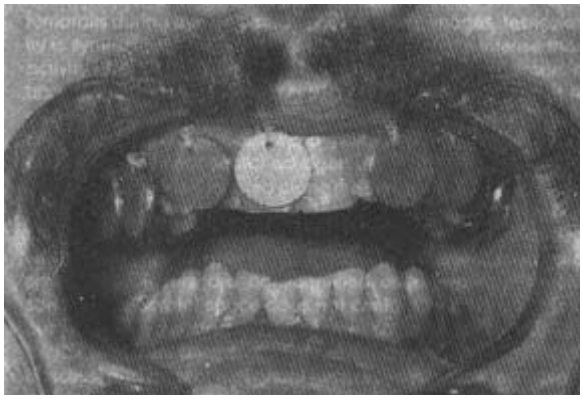
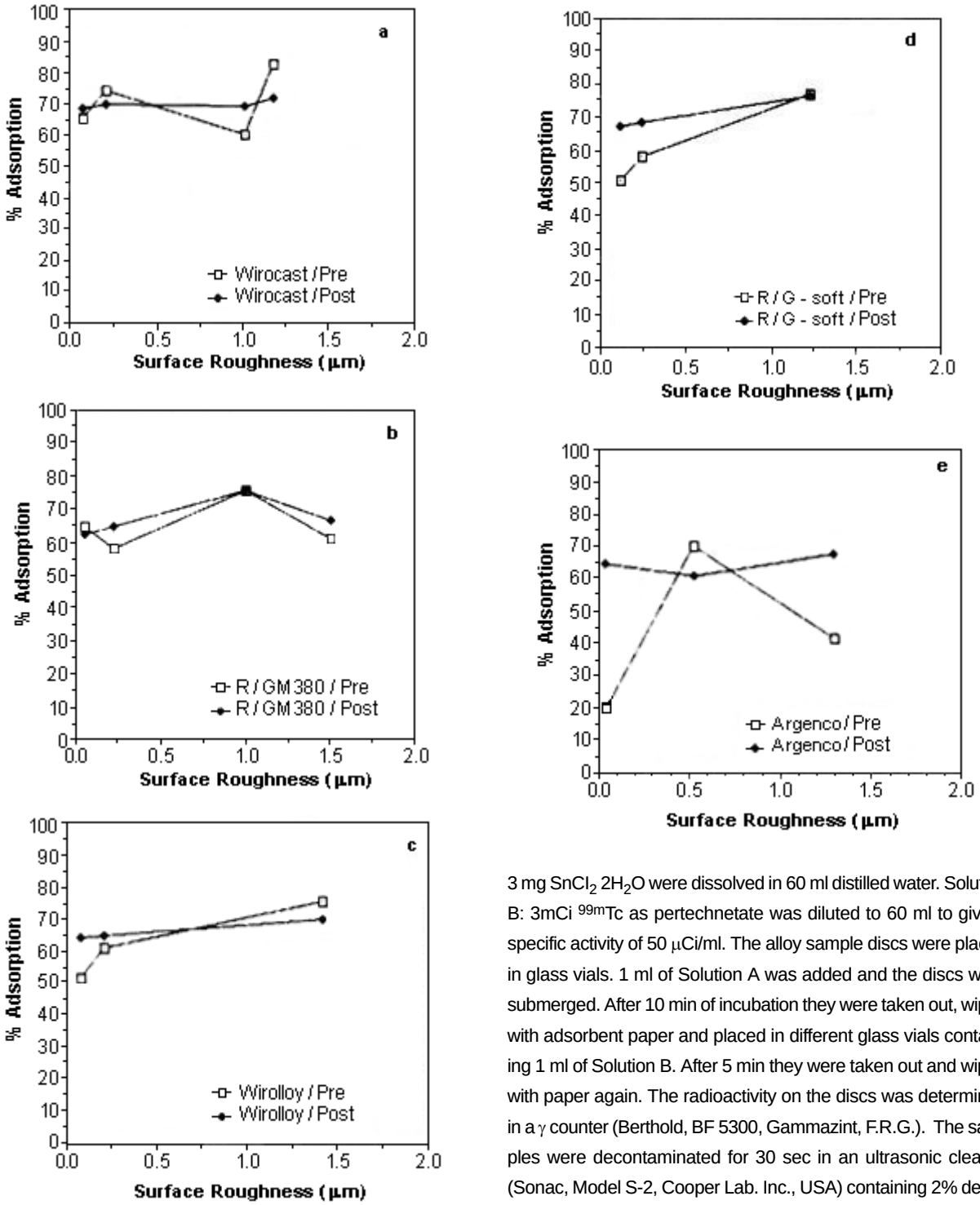


Figure 1: Sample discs on an acrylic plate in the mouth of a subject.

Figure 2: Variation in ^{99m}Tc-MDP adsorption patterns of different alloys as a function of surface roughness (R_a) (pre-and post-exposure to oral environment).



4. Measurement of ^{99m}Tc-MDP Adsorption:

a) Prior to exposure to oral environment: The method of Sanding and Endert (1983) was used. Two solutions were prepared. Solution A: 30mg methylenediphosphonic acid (MDP) and 3 mg $SnCl_2$ $2H_2O$ were dissolved in 60 ml distilled water. Solution B: 3mCi ^{99m}Tc as pertechnetate was diluted to 60 ml to give a specific activity of 50 μCi/ml. The alloy sample discs were placed in glass vials. 1 ml of Solution A was added and the discs were submerged. After 10 min of incubation they were taken out, wiped with adsorbent paper and placed in different glass vials containing 1 ml of Solution B. After 5 min they were taken out and wiped with paper again. The radioactivity on the discs was determined in a γ counter (Berthold, BF 5300, Gammazint, F.R.G.). The samples were decontaminated for 30 sec in an ultrasonic cleaner (Sonac, Model S-2, Cooper Lab. Inc., USA) containing 2% detergent. The counting was repeated against the standard (0.5 μCi in 1 ml) prepared from 1/100 dilution of Solution B. The % radioactivity remaining on the discs was calculated.

b) After exposure to oral environment: Three healthy subjects (all men, age range: 25-29 years) were included in this study after

Table 3 : % ^{99m}Tc - MDP Adsorption of alloy disks with various surface finishings before and after exposure to oral environment (*Mean ± SD).

		Exposure to oral environment						
	Before				After			
Alloy					Surface Finising			
	Sandblasted	Grinded	Polished	Electrolyzed	Sandblasted	Grinded	Polished	Electrolyzed
Wirocast	82.7±4.5	74.5±12.0	65.7±9.2	60.4±10.1	71.6±7.2	70.1±7.5	68.9±7.7	69.2±5.1
Remaium GM 380	75.4±13.7	57.7±15.8	64.5±16.8	60.8±11.5	75.9±5.2	64.5±5.3	62.4±6.6	66.5±5.2
Wirolloy	75.7±5.5	61.2±8.9	51.3±12.9		69.8±4.8	65.0±6.9	63.9±7.4	
Remanium G soft	76.7±5.7	58.1±8.8	50.5±12.0		76.4±6.7	68.3±6.4	66.8±10.1	
Argenco No 75	41.7±10.7	70.3±6.3	20.0±4.7		67.4±6.3	60.9±7.7	64.6±9.1	

Each value is a mean of 10 observations.

obtaining their informed consent. Acrylic plates with loops were placed in the upper vestibule (Figure 1). Ten alloy samples at a time were attached to the loops and left in the mouth for 2h. Afterwards they were taken out, washed for 15 sec with distilled water and air-dried. The above method to measure the percent radioactivity retention of the discs was repeated. The plates and the discs were cleaned in the ultrasonic cleaner with a prosthetic cleaner (Ultra Clean, Schein Inc., USA) before each in vivo application.

RESULTS

The mean surface roughness (R_a) values for all the alloys studied are summarized in Table 2. Within a given alloy there was a statistically significant difference ($p>0.01$ - $p>0.0001$) between the stages of surfacefinishing. The highest R_a values were obtained with the electrolyzed and sandblasted surfaces and the lowest with polished surfaces. R_{max} values followed the same pattern as R_a values. The results for % ^{99m}Tc-MDP adsorption for each stage of surface finishing both before and after exposure to oral environment are given in Table 3. When the mean values were statistically compared a significant difference ($p>0.05$-$p>0.001$) was obtained in 32 comparisons out of 52 before exposure of the samples to oral environment and in 26 comparisons afterwards. In the rest there was no statistical significance ($p<0.05$).

When the adsorption results were plotted as a function of surface roughness each alloy exhibited different adsorption characteristic (Figure 2). A similarity in adsorption pattern is observed between Wirocast and Remanium GM 380 which are both Co-Cr alloys (Figures 2a and b) and between Wirolloy and Remanium G-soft which are both Ni-Cr alloys (Figures c and d). The pattern obtained with argenco No. 75 (an Au-Ag-Pd alloy) is quite different (Figure 2e). The effect of oral environment on surface adsorption is displayed in the same figure, where the % adsorption reached a plateau, almost a common value, after exposure.

DISCUSSION

The effect of pellicle formation on the clinical adhesiveness of teeth and some dental materials was first emphasized by Jendresen and Glantz (8,9). They measured the critical surface tension of wetting of various selected dental materials before and after exposure to oral environment. After exposure the results were the same. They came to the conclusion that whatever the original surface chemistry, materials placed in the oral environment are brought to the same surface state by a mechanism of surface film adsorption. Although we used a different method, namely the % adsorption of a radioactive material, our conclusions are the same. % ^{99m}Tc-MDP adsorption was independent of the type of alloy used and of the extent of surface roughness once these materials were exposed to oral environment for a period of 2 h and thus covered by a biofilm. The present method, previously used by Sanding and Enderd (16) and Sandig, Endert and Pfister (17) is highly sensitive and reproducible. ^{99m}Tc with a physical half-life of 6 h and a gamma energy of 140 keV is an ideal radioisotope for both in vitro and in vivo studies.

In the present investigation we used alloys of different composition and of surface finishings. Surface roughness measurements with a profilometre indicated that the mean surface roughness (R_a) values were significantly different for each surface finish in a given alloy. Each alloy exhib-

ited a characteristic adsorption pattern when plotted as a function of surface roughness. Whatever the type and the original surface roughness of the alloy used, the adsorption reached the same level after 2h of exposure to oral environment.

REFERENCES

1. Baier RE, P-O Glantz: Characterization of Oral In Vivo Films Formed on Different Types of Solid Surfaces Acta Odontol Scand 36:289-301, 1978.

2. Clayton JA, E Green: Roughnesz of Pontic Materials and Dental Plaque J Prosth Dent 23:407-411, 1970.

3. Dowes C: The Nature of Dental Plaque, Films, and Calcareous Deposits Ann NY Acad Sci 153:102-119, 1968.

4. Dummer PM, KA Harrison: In Vitro Plaque on Commonly Used Dental Materials J Oral Rehabil 9:413-417, 1982.

5. Eichner K: Porzelanoberfläche - ihre Gestalt und ihre Auswirkung auf die Gingiva Dtsch Zannärztl Z 15:579-592, 1960.

6. Eichner K: Einfluss von Brückenzwieschengliedern auf die Gingiva Dtsch Zahnärztl Z 30:639-648, 1975.

7. Gildenhuys RR, RE Stallard: Comparison of Plaque Accumulation on Metal Restorative Surfaces Dent Surv 51:56-59, 1975.

8. Jendresen MD, P-O Glantz: Clinical Adhesiveness of the Tooth Surface Acta Odontol Scand 38:379-383, 1980.

9. Jendresen MD, P-O Glantz: Clinical Adhesiveness of Selected Dental Materials. An vivo Study Acta Odontol Scand 39:39-45, 1981.

10. Jörgensen E, E Theilade, J Theilade, J Kelstrup: Microbiology of Denture Plaque and Its Control by Chemical Agents Prot Stomat 30:243-248, 1980.

11. Jung F, L Hupfauf: Reaktionsvermägen des Mund höhlengewebes auf exogene Faktoren mit klinischen Hinweisen und therapeutischen Vorschlägen Dtsch Zahnärztl Z 16: 615-624, 1961.

12. Jung T: Die Oberfläche keramisch verblendeter Brükenkörper Dtsch Zahnarztl Z 30:653-659, 1975.

13. Maetani T, R Miyoshi, Y Nahara, Y Kawazoe, T Hamada: Plaque Accumulation on Teflon-Coated Metal J Prosth Dent 51:353-357, 1984.

14. Mayhall CW: Concerning the Composition and Source of the Acquired Enamel Pellicle of Human Teeth Archs Oral Biol. 15:1327-1341, 1970.

15. Meckel AH: The Nature and Importance of Organic Deposits on Dental Enamel Caries Res 2:104-114, 1968.

16. Sanding H-Ch, G Endert: Untersuchungen über Adhäsionseigenschaften stomatologischer Legierungen in Abhängnigkeit vom Bearbeitungszustand Zahn-Mund-u Kieferheilkd 71:463-469, 1983.

17. Sanding H-Ch, G Endert, W Pfisher: Untersuchungen über adhasive eingenschaften stomatologisher Legierungen nach mikrobieller Deckschichtbildung Zahn-Mund-u Kieferheilkd 71:694-699, 1983.

18. Sönju T, G Rölla: Chemical Analysis of the Acquired Pelicle Formed in Two Hours on Cleaned Human Teeth In Vivo Rate of Formation and Amino Acid Analysis Caries Res 7:30-38, 1973.

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