



EVALUATION OF SURFACE ROUGHNESS OF NICKEL CHROMIUM CASTING USING VARIOUS ABRASIVE POWDERS

Dental Science

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ABSTRACT

Purpose: A study was carried out to evaluate the surface roughness of nickel chromium castings before and after sandblasting with various abrasive powders. **Methodology:** A total of 30 samples made of nickel chromium were categorised into Group I, Group II and Group III based on abrasive powder used for sandblasting which were aluminium oxide, glass beads and 1:1 mixture of aluminium oxide and glass beads respectively. The surface roughness was measured before and after sandblasting for all the samples using profilometer. One sample before sandblasting and one sample from each group after sandblasting was subjected to scanning electron microscopic study and Energy Dispersive X-Ray Spectroscopy analysis. **Results:** Statistical comparison of the mean surface roughness between the groups before and after sandblasting was done. **Conclusion:** Within the limitation of the study it is concluded that use of abrasive powders has an effect on the surface roughness of the Nickel Chromium castings. Therefore, careful consideration must be done on the type of abrasive powders selected for the good finishing of the final restoration.

KEYWORDS:

Surface roughness, Nickel chromium, Scanning electron microscope, Energy Dispersive X-Ray Spectroscopy

INTRODUCTION

The most principle factor for all the fixed prosthodontics material is their permanent existence in the oral cavity and its longevity without the ability of being removed by the patient.^[1]

Nickel chromium (Ni-Cr), is an alloy of nickel and chromium. When heated to red hot temperature Ni-Cr develops an outer layer of chromium oxide.

Surface roughness a component of surface texture is measured by manual comparison against a "surface roughness comparator", a sample of known surface roughness's using a profilometer.

Sand blasting of castings is a routine procedure in dental laboratories to remove retained investment material. Various abrasive powders such as carborandum, aluminium oxide and glass beads have being used for sandblasting. The divesting of the casting is usually carried out in two steps: first, with a hard powder and second with a softer powder both having effects on the surface texture.

As the literature lacks in the aspect of the effect of sandblasting using mixed powder composed of aluminium oxide and glass beads on Ni-Cr castings, this study is intended to evaluate and compare the surface roughness of Ni-Cr castings after sandblasting with various abrasive powders which are aluminium oxide, glass beads and mixture (1:1) of aluminium oxide and glass beads.

AIMS AND OBJECTIVES

1. To evaluate the surface roughness of Ni-Cr castings before and after sandblasting.
2. To compare the surface roughness of Ni-Cr castings using three different abrasive powders after sandblasting.
3. To perform elemental analysis on the surface of Ni-Cr castings after sandblasting treatment.

METHODOLOGY

Source of data:

This in vitro study was conducted on 30 Ni-Cr castings fabricated in Department of Prosthodontics A B Shetty Memorial Institute of Dental Sciences. Pure Ni-Cr alloy castings with accurate dimensions were included in the study. Castings with porosities, incomplete castings, distorted castings, deficient castings were excluded from the study.

30 wax patterns were prepared measuring 1 cm in length and breadth and 2mm thickness using modelling wax. Wax patterns were invested using phosphate bonded investment material and casted using Ni-Cr alloy and subjected to acid treatment the a solution of Concentrated H₂SO₄+Conc HNO₃ for 30 minutes for removal of investment material from the surface of the casting. All the samples were then evaluated for surface roughness using a profilometer before sandblasting and one sample was subjected to elemental analysis using Energy Dispersive X-Ray Spectroscopy (EDS) and Scanning Electron Microscopic (SEM) analysis (Figure 1a).

The samples were then divided into three groups of 10 samples each and were sandblasted. Group I samples were sandblasted using aluminium oxide (120µm), Group II samples using glass beads (125 µm) and Group III samples using 1:1 mixture of aluminium oxide and glass beads for fixed period of time, fixed distance and constant pressure. Samples from each group were evaluated for surface roughness using a profilometer and one sample from each group was subjected to elemental analysis using EDS and SEM analysis (Figure 1b-1c)

RESULTS

In this study the surface roughness of Ni-Cr castings before and after sandblasting with three abrasive powders were evaluated and compared using the profilometer.

Data analysis:

The data collected was subjected to one way ANOVA test for

comparison of the mean surface roughness between the groups before and after sandblasting and subsequently pairwise comparisons were performed between the test groups by using Tukey Post Hoc test. A p value < 0.05 was considered as statistically significant.

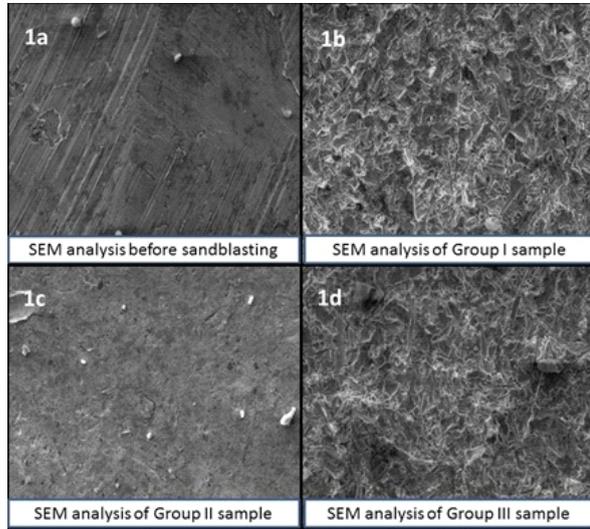


Table 1 represents a comparison of mean surface roughness value between the study groups before and after sandblasting

	Group	N	Mean	SD	Min	Max	ANOVA	
							F	p-value
Pre	I	10	1.3545	0.1038	1.1932	1.4920	0.04	0.96(NS)
	II	10	1.3650	0.0769	1.1983	1.4693		
	III	10	1.3552	0.0874	1.1316	1.4279		
Post	I	10	1.1603	0.0730	0.9909	1.2414	114.47	<0.001*
	II	10	0.6304	0.0949	0.4895	0.7425		
	III	10	1.0290	0.0750	0.9576	1.1987		

*p<0.05 statistically significant, p>0.05 Non significant, NS

Table 2 represents a pairwise comparison of mean surface roughness value between the study groups after sandblasting

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Post I	II	0.5298	0.036	<0.001*	0.4394	0.6202
	III	0.1313	0.036	0.004*	0.0409	0.2217
II	III	-0.3986	0.036	<0.001*	-0.4890	-0.3081

Tukey Post Hoc test

*p<0.05 Statistically significant, p>0.05 Non significant, NS

Table 3 represents a comparison of change in mean surface roughness value between the study groups

Group	N	Mean	Std. Deviation	Minimum	Maximum	F	p-value
I	10	0.1942	0.1243	-0.0455	0.3254	42.334	<0.001*
II	10	0.7345	0.1300	0.5236	0.9075		
III	10	0.3262	0.1545	-0.0671	0.4703		

*p<0.05 Statistically significant, p>0.05 Non significant, NS

Table 4 represents the pairwise comparison of change in mean surface roughness between the groups.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
I	II	-0.5403	0.0612	<0.001*	-0.6921	-0.3885
	III	-0.1320	0.0612	0.09(NS)	-0.2838	0.0198
II	III	0.4083	0.0612	<0.001*	0.2565	0.5601

Tukey Post Hoc test

*p<0.05 Statistically significant, p>0.05 Non significant, NS

The weight percentages of aluminium and oxygen were mainly evaluated during EDS.

Table 5 shows the weight percentages of aluminium and oxygen in four samples.

Sample	WEIGHT PERCENTAGE	
	Aluminium	Oxygen
Pre sandblasting	0.00	2.18
Group I	7.48	12.07
Group II	0.76	8.77
Group III	10.58	15.98

DISCUSSION

Cobalt chromium and Ni-Cr alloys have been used extensively for fabricating partial denture frameworks and have replaced type IV gold alloys.^[2]

Nickel in combination with chromium shows increased resistance to corrosion and hardens the alloy. Ni-Cr when compared to cobalt-chromium alloys and gold alloy have desirable characteristics and superior sag resistance.^[3]

The performance of an abrasive powder is determined by the size, shape and hardness of the particles. Harder the abrasive particles better is the performance. The particle size also plays an important role as they have impact energy and when they hit the surface they generate defect on the surface, hence larger the size larger the defect on the surface of the alloy. Particles with angular shape causes rougher surface when compared to that of particles with round shape.^[4]

Aluminium oxide an abrasive agent has more abrasiveness property than glass beads and causes severe damage to the surface of the alloy leading to increased surface irregularities. To prevent these damages abrasive agents like glass beads that are spherical in nature can be used. The rougher the surface, increased opportunity for plaque adhesion.^[5,6]

Yoshiaki Taga et al[7] investigated the efficiency of sandblasting with different types of abrasive agents and concluded that sandblasting cobalt-chromium alloy castings with mixture of aluminium oxide and glass beads decreased the treatment time and also resulted in smooth surface of the casting. Studies have also proved the importance of smooth surface finish of the frameworks to prevent retention of microorganisms.^[8]

In the present study statistical analysis of roughness values of samples of the three groups obtained by profilometer showed no significant difference before the sandblast but indicated that there was a significant difference in the mean surface roughness between the groups after sandblast. It was also seen that there was significant difference in the mean surface roughness values between the sample groups after sandblast using different abrasive powders. This change in the surface roughness after sandblasting may be due to the

alterations in the surface composition of the samples because of the reactions with the abrasive powder.

The SEM image of the sample sandblasted with glass bead showed smoother surface than those sandblasted with aluminium oxide and mixed powder. The samples sandblasted by aluminium oxide produced the roughest surface. This is due to two properties of the abrasive particles which are particle shape and hardness. The hardness of glass beads is less than that of aluminium oxide. Glass beads are spherical in shape and produce a smoother surface than the aluminium oxide particles that are angular in shape.

EDS is a technique that helps in analysing the weight percentage of oxygen and other elements. The weight percentage of oxygen is usually highest prior to sandblasting treatment but in this study the oxygen content was found to be the least. This may be due to trimming of the castings before sand blasting which would have removed the surface oxide layers. The composition and reliability of the surface oxide layer formed is crucial for the long term success of the Ni-Cr casting alloy. The damage to this surface oxide layer increases the degree of corrosion and thus increases the risk of toxicity to the perioral tissue.^[9]

Clinical implications of the study:

- a) This study highlighted the effect of various abrasive powders on the surface roughness of [Ni-Cr castings](#).
- b) The finishing condition of the [Ni-Cr alloy has important clinical implication when placed clinically and when are in direct contact with the perioral tissues for a prolonged period of time](#).
- c) The surface roughness caused by brushing can cause increase plaque and calculus retention and causing failure of prosthesis.
- d) Mixture of aluminium oxide and glass beads produces lesser surface irregularities on the casting than aluminium oxide powders and also produced less contamination on the surface. So its use in general laboratory practice may be done as it has many advantages.

CONCLUSIONS:

Within the limitations of the study it can be concluded that there was no significant difference between the castings before sandblasting. After the sandblasting treatment it was noticed that the surface roughness reduced to a certain extent and investment residues were removed by the abrasive agents.

However, there is a further scope of the study to evaluate the effect of duration of sandblasting on titanium castings which might produce different results. Also the effect of surface roughness on the biocompatibility of Ni-Cr castings can be further evaluated.

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