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AN EVALUATION OF THE MARGINAL ACCURACY AND SURFACE ROUGHNESS OF NICKEL CHROMIUM COPINGS FABRICATED BY CONVENTIONAL AND ACCELERATED CASTING TECHNIQUES

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ABSTRACT

Purpose: A study was carried out to measure the marginal discrepancy and surface roughness of nickel chromium castings fabricated by conventional and accelerated casting techniques.

Methodology: A total of 30 patterns were prepared using inlay casting wax patterns to obtain a uniform thickness of 0.5mm as recommended. All the patterns were subjected to casting procedures.15 castings were invested using conventional casting and 15 were invested using accelerated casting. The cast copings were devested, sandblasted and steam cleaned. The fabricated cast copings were grouped as Group I, Group II. The vertical and marginal gap of the cast copings were evaluated microscopically and measured at 4 predetermined reference points using a stereo optical microscope at 32x magnification. The surface roughness was also measured using a contact profilometer on the castings obtained from the both the conventional and accelerated casting techniques. The data was subjected to descriptive statistics and independent sample 't' test. A p value < 0.05 was considered as statistically significant.

Results: Statistical comparison of the mean marginal discrepancy and surface roughness between the groups was done. The values of the samples obtained were statistically analysed using independent sample 't test'. There was significant difference between the study groups in marginal discrepancy of conventional and accelerated castings..A significant difference was noted in surface roughness values between these two groups. Copings fabricated by conventional casting techniques had lower values of marginal discrepancy and surface roughness as compared to copings fabricated by accelerated castings but these values were within the clinically acceptable range.

Conclusion: Within the limitation of the study, it is concluded accelerated casting offers us a time saving technique which is beneficial for the patient, lab technician and the dentist.

KEYWORDS : Surface roughness, marginal discrepancy, nickel chromium, profilometer and accelerated casting.

Introduction

Proper marginal fit of the overlying casted coping or crown in relation to the prepared tooth is one of the most important factor for the mechanical, biological and esthetic success and longevity of a fixed dental prosthesis[1,2]. The marginal fit is affected by various clinical and laboratory procedures, starting from definite margins in the tooth preparation which must be recorded by an accurate impression, precise wax patterns and castings leading upto finishing, polishing and cementation of the prosthesis[3,4].

Utmost attentiveness has been given to various laboratory and clinical procedures, while casting the wax patterns, but it becomes inevitable to avoid marginal discrepancy. Clinically and biologically acceptable values in marginal discrepancy in copings and crowns range from 10-160um[5]

Surface roughness of a Ni-Cr coping can be on the exterior surface or the interior surface. Internal surface roughness or even a small nodule can indirectly result in marginal gap width, and even can limit uniform space for luting cement.

The patient, dentist and dental laboratory technician have several advantages if they achieve similar result in less time Accelerated/ short, nonstandard casting technique has been studied in an effort to achieve similar quality. The pattern is invested, cast, and delivered in a cost-effective and in a time saving manner.

Most of these studies have reported the effect of accelerated casting procedures on the fit of noble alloy castings. However, the effect of accelerated procedures on the marginal fit of base metal alloy restorations has not been adequately studied.

So, it is thought desirable to undertake the present study with different bench set and different burnout temperatures to investigate their effects on marginal fit and surface roughness.

Materials and Methodology

This in vitro study was conducted in Department of Prosthodontics, A.B. Shetty Memorial Institute of Dental Sciences, Nitte University, Mangaluru, on a total of 30 nickel chromium castings designed on a metal master die which simulates a complete molar crown preparation. The surface roughness measurement was done in by using profilometer and marginal discrepancy was measured using optical microscope .

Description of custom made stainless steel master die

A customized stainless steel master die was prepared simulating the shape and dimension of tooth preparations resembling a first molar.(Fig 1). The die measured 6 mm from the occlusal surface to finish line with a 6° taper towards the occlusal surface from the finish line. The metal die was mounted on a cylindrical base of 20 mm length and a diameter of 10 mm.Reference marks were scribed in predetermined areas near the cervical margin around the circumference of the die. These marks were used later as reference marks for the measurements.

Wax patterns were fabricated on the master die.They were divided into 2 groups with 15 wax patterns in each group.

GROUP 1: Representing castings made following conventional casting techniques.
GROUP 2: Representing castings made following accelerated casting techniques.

The customized stainless steel die assembly as described previously was used to obtain standardized patterns for all the test specimens

employed in this study. The inlay casting was melted and filled in the stainless steel former and was pressed on the stainless steel die. The stainless steel and former assembly were held together for 1 minute with finger pressure. The die was then separated from the former and the wax pattern was obtained(Fig 2). All the test pattern copings were invested individually using phosphate bonded investment material.

Bench set following investment

Group I: Before burnout, the investment was allowed to set for 2-3 hours.

Group II: Before burnout, the investment was allowed to set for 13-17 minutes.

Burnout for conventional casting

The set investment was placed in the burnout furnace, after a 20 minute bench set time. A programmed preheating technique was used for the wax pattern elimination. The investment was kept in the furnace at room temperature and was heated continuously till 950 degree Celsius at the rate of 8 degree Celsius per minute.

Burnout for accelerated casting

For the accelerated casting technique ,after the bench set time of 20 minutes, the set investment was placed in the burnout furnace (Sirio Dental SNC, Italy). The molds were placed, in an oven which was preheated to 815 degree Celsius for 20 minutes.

All the 30 copings were then casted in an induction casting machine and were deinvested and finished and polished.

Maximum distance was determined between the tooth preparation margin and the most apical part of the casting margin in a plane parallel to the long axis of the tooth to measure the vertical marginal discrepancy(Fig 3).

Quantitative evaluation of surface roughness was done by Contact profilometer. Each cast coping was placed under the stylus of the profilometer. The stylus moved along the coping at predetermined areas on the outer aspect .The values of surface roughness were shown in the Taylor Hobson software attached to the profilometer (Fig 4).

Fig 1

Fig 2

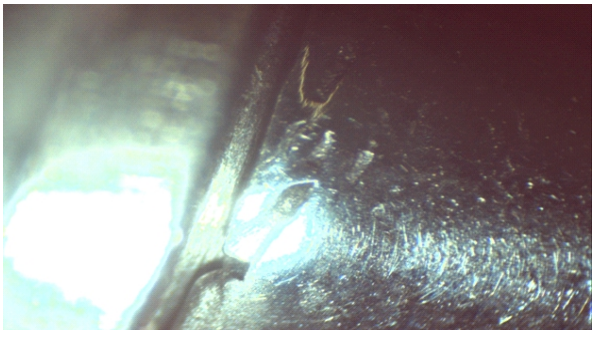

Fig 3

Fig 4

Results

Mean Vertical marginal gap for group 1 test samples : 44.6536
Mean vertical marginal gap for Group II test samples : 53.758

The mean obtained from Group II samples (53.758um) was higher than mean obtained from Group I samples. (44.6536).

Mean surface roughness(Ra value) for group 1(G1) test samples Mean Value(R_A) 0.2542 um

Mean surface roughness(Ra value) for group 2(G2) test samples. Mean Value($R_{A)}$: 0. 5659 um

When the marginal discrepancy values of Group I and II were put up for statistical analysis, it was found that the difference was statistically significant. (P<0.01). Also, the difference between surface roughness values($R_{A)}$ between group I and II was also significant.(P<0.01).

Table 1

	Group	N	Mean	Std. Deviation	Mean Difference (95% CI)	t	df	p-value
Marginal Discrepancy	1	15	44.10	2.29	-9.66 (-11.23, -8.09)	-12.62	28	<0.001*
	2	15	53.76	1.88				
Surface Rougness	1	15	0.25	0.07	-0.31 (-0.40, -0.22)	-7.18	28	<0.001*
	2	15	0.57	0.16				

Discussion

The majority of the fixed partial dentures are fabricated using conventional investing and casting techniques, which usually require at least 1 hour setting time for the investment, followed by two stage (temperature is increased from room temperature to 250°C and held for 60 min and then the temperature is increased to 950°C gradually(and held for 30 min) or wax elimination procedure before casting is done.

The whole process requires approximately 2 to 4 hours for completion and is time-consuming.

A modified technique called accelerated casting technique have been reported with comparable results. The accuracy of fit of a cast restoration is essential for its clinical success and longevity because it allows for less plaque accumulation at the marginal area, provides better mechanical properties, less exposure of cement to the oral environment and better esthetic result.

Marzouk and Kerby attempted the accelerated casting technique with the use of a phosphate-bonded investment. They concluded that the accelerated casting technique requires 30 to 40 minutes whereas, conventional casting technique requires 2 to 4 hours[6,7]

Later many studies were carried out to evaluate the marginal accuracy of complete crowns made with gold alloys using' a phosphate-bonded investment and accelerated casting method, and they ended up with comparable results.

In this study a total of 30 patterns were prepared using inlay casting wax patterns to obtain a uniform thickness of 0.5mm as recommended. All the patterns were subjected to casting procedures.15 castings were invested using conventional casting and 15 were invested using accelerated casting. The cast copings were devested, sandblasted and steam cleaned.

The fabricated cast copings were grouped as Group I, Group II. The Ni-Cr cast copings were seated by the same operator on the stainless steel die with finger pressure. The marginal gap of the cast copings were evaluated microscopically and measured at 4 predetermined reference points using a optical microscope at 32x magnification. The results obtained were tabulated and statistically analyzed.

The basic data obtained in this study shows a mean vertical marginal gap of 44.5260 microns for casting obtained by conventional casting(G1), 53.758 microns for casting obtained by accelerated casting.(G2).

The vertical marginal gap of all the 30 copings obtained by 2 different pattern forming methods showed a statistically significant difference between the two test groups. Statistical significant difference was present between Group I and Group II.

Konstantoulakis[6] et al conducted a study to check the marginal fit and surface roughness of complete crowns made with a conventional and an accelerated casting technique and obtained a mean marginal discrepancy of 122 u +_ 156.6 and 148.3 +_ 158.6 respectively and they showed a mean difference of 26.2 u +_ 91.0 um

Blackman et al evaluated the dimensional changes and surface roughness of gold crowns cast with rapidly prepared phosphate bonded investments, and the mean marginal loss for the conventional and accelerated casting when compared with the wax patterns was 17.3 u +_ 5.9 and 27.1 u +_ 3.7 respectively.[11]

The accelerated castings show more marginal discrepancy than the conventional castings, but previous studies have stated that these marginal discrepancy values are well within the clinaically acceptable limits.

The mean vertical marginal discrepancies of Conventional and Accelerated castings were compared, and statistically significant differences were found between the mean vertical marginal discrepancies of Conventional and Accelerated castings (P<0.001). Clinical tolerance limits for the fit and marginal adaptation of a cast restoration are actually not known. However, several investigations reported that marginal gaps in cast cr In the present study it was found that the marginal gap was of 44.6536 microns(G I) and 53.758 microns (G II) for castings obtained by conventional castings and accelerated castings respectively. These values were significant as shown in the previous studies. But these values are well within the clinical tolerance limit and were consistent with earlier research.

Surface roughness values were also measured in this study between copings fabricated from conventional technique(G I) and accelerated casting technique(G II).Statistical comparison was done between the values obtained from both the groups which were significant.

A study was done by Konstantoulakis et al, in the third part of their study they evaluated the surface roughness of castings made by conventional and accelerated technique. The measurement obtained by the authors between the two groups were not statistically significant.[6]

Limitations of the study

However there are few limitations in this study. The laboratory testing cannot exactly reproduce the clinical situation. In this study, the marginal discrepancy was measured without permanent cementation of the cast copings and it could potentially affect the marginal adaptation. In order to reproduce the clinical condition, Jogersen suggested that any study aimed at determining the marginal adaptation of a crown system requires the cementation of crowns.

Conclusions and Summary

The following conclusions were drawn from the data obtained in this in vitro study which was conducted to comparatively evaluate the marginal fit and surface roughness of Ni-Cr copings obtained by two different casting and investing methods, using conventional and accelerated casting.

Conclusions:

- A vertical marginal gap was observed with all the 30 Ni-Cr copings obtained by 2 different methods.
- The vertical marginal gap of the 15 cast copings obtained from conventional casting technique(G1) showed a mean value of 44.6536 um.
- The vertical marginal gap of 15 cast copings obtained form accelerated casting technique(G2) showed a mean value 53.758 um.
- The Mean Value for Surface roughness ($R_{A)}$ in micrometers for Group 1 (G1) test sample : 0.2542 micrometer.
- The Mean Value for Surface roughness ($R_{A)}$ in micrometers for Group 2 (G2) test sample : 0.5659 micrometer.

The vertical marginal gaps of cast copings obtained by the 2 different methods were statistically significant to each other. The copings obtained from accelerated casting showed a significantly higher value than conventional castings. The mean vertical gaps of both the groups were within clinically acceptable range(35 – 60 um).

This in vitro study revealed that the marginal fit of the Ni- Cr copings fabricated form the 2 methods were in the range of clinically acceptable for longevity of the restorations.

Significant results were obtained for surface roughness for Group I and Group II with the mean of 0.2542 micrometer and 0.5659 micrometer respectively. However these results were found within the normal limits.

This study showed that the statistical values of marginal discrepancy and surface roughness between the two groups were significant but they were well within the clinically acceptable values. So accelerated casting offers us a time saving technique which is beneficial for the patient.lab technician and the dentist.

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