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Original Article

Evaluation of Marginal fit of castings made with an accelerated Casting technique using reusable alloys in different percentages – In Vitro study

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ABSTRACT

Background: Reusing of alloy has become a need of time due to the increasing demand, depletion of resources and substantial increase in their price. In this study, marginal accuracy of castings fabricated by reusing the alloy in different percentages to the new alloy along with acceleratd casting technique was compared. **Materials and Methods:** 30 wax patterns were fabricated and the marginal discrepancy between the die and the patterns was measured using an optical stereomicroscope. Ten wax patterns were cast using 25%by weight of reusable alloy, ten were cast using 50%by weight of reusable alloy and ten were cast using new alloy. A nickel-chromium alloy with accelerated casting technique was used. The marginal discrepancy of the castings was measured and compared. **Results:** The vertical marginal discrepancy of the castings obtained by using new alloy was less compared to the other two groups. **Conclusion:** Castings produced using new alloy were better than those obtained with reused alloy. The vertical marginal discrepancy of all the three groups was well within the maximum clinical tolerance limits. **Clinical implication:** Alloys can be reused till 50% by weight along with the new alloy and accelerated casting technique can be used to save the lab time to fabricate castings with acceptable vertical marginal discrepancy.

Introduction

The base metal alloys were introduced in dentistry in 1930 by R.W. Eardle and C.H.Prange. These alloys were then so inexpensive that every time casting was performed using new alloy ingot and left over metal was either discarded or sold back to the supplier by weight. But presently due to the increasing demand for the base metal alloys their price has substantially increased. Therefore it will be of great advantage, both economically and environmentally, to recycle or to recast the alloy again and again with or without adding a new alloy.

Various reports have been published about reusing the alloy in different percentages, however majority of them deal with the so-called "conventional" investing and casting techniques.[1,2,3,4,5,6,7,8]

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Figure 1: Master Die

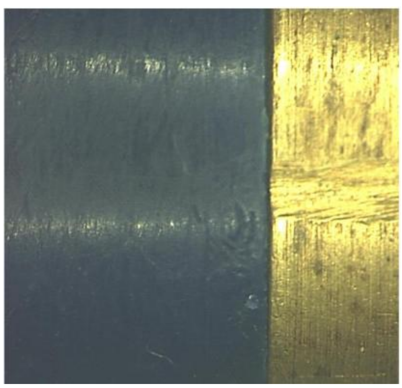

Figure 2: Measurement of marginal gap of wax pattern using optical stereomicroscope

Figure 3: Recovered Group 1, Group 2 and Group 3 castings

Figure 4: Casting on master die.

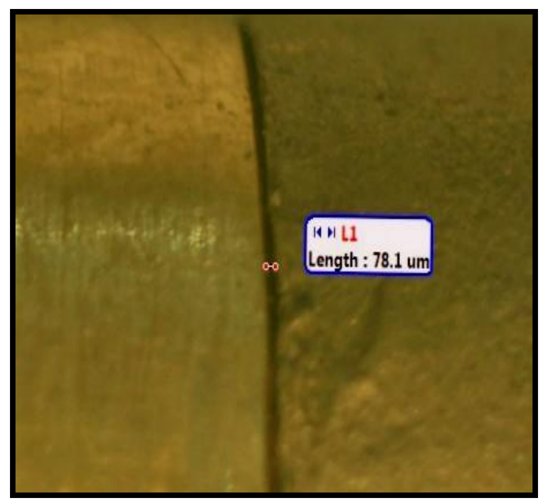

Figure 5: Measurement of marginal gap of casting using optical stereomicroscope.

Accelerated casting technique have been reported in an effort to achieve similar quality results in significantly less time, namely in 30 to 40 minutes for the fabrication of High noble alloy crowns. A published attempt to accelerate the lost wax technique with the use of phosphate bonded investment for a complete crown was made in 1988 by Marzouk and Kerby.[9]

This study evaluated the marginal accuracy of full coverage single crowns made with an accelerated casting technique that uses phosphate bonded investment material and a Ni-Cr alloy in 25% by

Table 1: Paired comparison of vertical marginal discrepancy (μm) between wax patterns and after casting at Buccal, mesial, lingual and distal areas in Group 1

Group 1	Wax mean±S.D	Casting mean±S.D	Difference mean±S.D	t value	p value
Buccal	9.03±0.84	86.50±13.74	-77.48±13.55	-18.078	<0.001(VHS)
Mesial	9.66±1.17	89.01±16.07	-79.34±15.34	-16.353	<0.001(VHS)
Lingual	9.55±0.98	89.30±15.17	-79.74±14.61	-17.256	<0.001(VHS)
Distal	9.42±1.33	88.92±14.09	-79.50±13.36	-18.816	<0.001(VHS)

Table 2: Paired comparison of vertical marginal discrepancy (μm) between wax patterns and after casting at Buccal, mesial, lingual and distal areas in Group 2

Group 2	Wax mean±S.D	Casting mean±S.D	Difference mean±S.D	t value	p value
Buccal	8.14±0.82	93.24±15.56	-85.10±15.74	-17.101	<0.001(VHS)
Mesial	8.10±0.84	92.71±15.66	-84.61±15.91	-16.820	<0.001(VHS)
Lingual	8.15±0.81	91.28±11.79	-83.13±11.90	-22.086	<0.001(VHS)
Distal	8.17±0.87	93.41±12.78	-85.24±12.84	-20.996	<0.001(VHS)

weight and 50% by weight concentration along with the new alloy.

Materials and methods

A precisely machined brass master die was fabricated. The die measured 8 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 8 mm. A shallow axial groove was given for orientation of casting during seating. Four reference marks were scribed one each on the buccal, lingual, mesial and distal areas on the root stump near the cervical margin around the circumference of the die. These marks were used later as reference marks for the measurements.[10] **(Figure 1)**

The Wax patterns were fabricated after applying a thin layer of die lubricant. The margins were readapted and refined using wax carving instruments and divided into 3 groups, with 10 wax patterns in each group.

Group1: Representing castings made following accelerated Casting technique using pure alloy.

Group 2: Representing castings made following Accelerated Casting technique using 25% by weight of reusable alloy.

Group 3: Representing castings made following Accelerated Casting technique using 50% by weight of reusable alloy.

The marginal discrepancy between the metal die and the wax pattern were measured on an Optical stereomicroscope **(Figure 2)** at predetermined areas that were marked on the metal die.

Table 3: Paired comparison of vertical marginal discrepancy (µm) between wax patterns and after casting at Buccal, mesial, lingual and distal areas in Group 3.

Group 3	Wax mean±S.D	Casting mean±S.D	Difference mean±S.D	t value	p value
Buccal	8.53±0.88	96.40±9.10	-87.87±8.61	-32.276	<0.001(VHS)
Mesial	8.43±0.83	96.64±9.19	-88.21±8.71	-32.041	<0.001(VHS)
Lingual	8.49±0.83	96.03±8.45	-87.54±7.84	-35.317	<0.001(VHS)
Distal	8.51±0.86	96.08±8.51	-87.57±7.94	-34.868	<0.001(VHS)

Table 4: Paired comparison of Average vertical marginal discrepancy (µm) between wax patterns and after casting in three Groups.

Average	Wax mean±S.D	Casting mean±S.D	Difference mean±S.D	t value	p value
Group 1	9.42±0.98	88.43±14.11	-79.02±13.58	-18.398	<0.001(VHS)
Group 2	8.14±0.83	92.66±13.80	-84.52±13.95	-19.166	<0.001(VHS)
Group 3	8.49±0.84	96.29±8.63	-87.80±8.09	-34.337	<0.001(VHS)

The wax patterns were sprued. Group 1, Group 2 and Group 3 wax patterns were invested individually using ringless technique. They were invested with Bellavest SH (BEGO, Germany) phosphate-bonded investment (60gm of powder to 16 ml of 100% mixing liquid).

The investment was allowed to set for 13 to 17 min then the moulds were removed from the plastic ring before proceeding with burnout.After 13 to 17 minutes of initial setting the moulds were placed in a burnout furnace at a pre-heated temperature of 815 ^{0}C for 15 minutes.[11, 12, 13, 14]

After completion of the burnout the casting procedure was carried out in an induction-casting machine using Ni-Cr alloy.

The castings were recovered**(Figure 3)** by divesting the investment. Burs were used to remove the investment from the inner surface of the casting such as a thin layer of investment left behind. Sandblasting was done to remove the residual investment and oxide layer.

The completed castings were seated on the metal die under finger pressure **(Figure 4).** The marginal discrepancy between the metal die and the castings were measured on an Optical stereo microscope at predetermined points using Motic plus software **(Figure 5).**

Results

The castings fabricated using new alloy showed less vertical marginal discrepancy (88.43±14.11) than the castings fabricated using 25%by weight

Table 5: Comparison of mean vertical marginal discrepancy (μm) in between the 3 groups by analysis of variance (ANOVA).

	Sum of Squares	df	Mean Square	F	p value	Interpretation
Wax Buccal	3.911	2	1.956	2.731	0.083	NS
Wax Mesial	13.617	2	6.808	7.378	0.003	HS
Wax Lingual	10.746	2	5.373	6.984	0.004	HS
Wax Distal	8.386	2	4.193	3.856	0.034	S
AVG WAX	8.701	2	4.351	5.572	0.009	HS
Casting Buccal	511.189	2	255.594	1.493	0.243	NS
Casting Mesial	291.475	2	145.737	0.744	0.485	NS
Casting Lingual	239.406	2	119.703	0.815	0.453	NS
Casting Distal	261.693	2	130.847	0.904	0.417	NS
AVG CASTING	309.143	2	154.572	0.999	0.381	NS

(92.66±13.80) and 50%by weight (96.29±8.63) of used alloy with new alloy**(Table 1,2,3,4)**. There was statistically no significant ($p>0.05$) difference in between either 2 of the 3 groups.**(Table 5)**

Discussion:

Fixed Prosthodontics has become a major part of current restorative dentistry because people are living longer, seeking more dental care, and are more educated about their dental health. In view of their convenience and psychological and social advantages, patients prefer reconstruction with fixed partial dentures (FPDs) rather than removable ones**.**

The present demand for the base metal alloys has resulted in a substantial increase in there price. Apart from the cost due to environmental factors and deprivation of the resources every material is being tried to reuse for various purposes. Therefore efforts are being made to recycle or to recast the alloy again and again with or without adding a new alloy. Repeated casting has shown more stability in noble and nickel-based alloys in comparison with the high noble alloys.[3] Recasting of nickel-chromium alloys has revealed no meaningful effect on their castability.[1]Moreover consecutive recasting of the nickel based alloy has demonstrated great stability in terms of their chemical composition, microstructure, microhardness, and ion release.[7]

The majority of the fixed partial dentures are fabricated using “conventional” investing and casting techniques, which requires approximately 2-4 hrs.for the complete procedure. A modified technique called accelerated casting technique has been reported with comparable results.[11, 12, 15, 14, 16.]

This study was conducted to evaluate the marginal accuracy/fit/discrepancy of full coverage single crowns made with an accelerated casting technique that uses phosphate bonded investment material and a Ni-Cr alloy in 25%by weight and 50% by weight concentration along with the new alloy.

In this study the mean vertical marginal discrepancy of group 1, group 2 and group 3 wax patterns ranged from 7.68µ to 12.50µ, 7.68µ to 9.76µ and 7.24µ to 9.92µ respectively. This discrepancy can be due to the following reasons.

During fabrication and removal of the pattern from the die, wax pattern is most likely to get distorted due to the thermal changes and the relaxation of stresses that are caused by contraction on cooling, occluded air in the wax, molding, carving, removal, and the time and temperature of storage.[17]

The distortion of the wax patterns can be minimized bylowering storage temperature and by investing immediately after fabrication.[13, 17, 18]

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 crowns of up to 74 µ, 104 µ, or 120 µ are considered to be clinically acceptable.[11]

In the present study mean vertical marginal opening was 88.43±14.11, 92.66±13.80 and 96.29±8.63 for group 1 castings, group 2 castings and group 3 castings respectively, these values are within clinical tolerance limits. The difference in the readings can be attributed to various factors such as setting expansion, thermal expansion, shrinkage of wax and alloy, various properties like oxidization, vaporization and porosity of the recast alloy. The influence of all these above factors except the properties of recast alloy was same on all the three groups as the procedure followed was similar. Group 2 and group 3 had an additional influence of recasting the alloy.

The phosphate investment binder chemistry is fairly complex and results in a very energetic reaction. Phosphate bonded investment reacts with water and exhibits shrinkage. This contraction is practically eliminated when colloidal silica solution replaces water. Various authors have confirmed the elevated thermal expansion with the use of special liquid for mixing investment. The expansion can be variedby the proportions of silica solution and water: Phosphate-bonded investment mixed with 100% special liquid resulted in higher heat and higher settingexpansion.[19]In the present study 100% special liquid was used for the investment.

In the ringless technique, a soft plasticized PVC or elastomeric ring is used to support and confine the investment material until it attains sufficient green strength. Thereafter, the restrictions are removed to allow isotropic thermal and setting investment expansion. The vertical marginal gaps obtained in the ringless casting groups were significantly less than those of the metal ring casting groups.[20]

Accelerated schedules may take advantage of the characteristic exothermal setting reaction of Phosphate bonded investment materials. Heat-enhanced setting expansion continues uninterrupted as the mold is transferred into a preheated furnace environment for thermal expansion. The importance of introducing the mold into the preheated oven when the investment has reached its peak temperature was first emphasized by Marzouk and Kerby. When the investment reaches its maximum exothermic setting reaction temperature, most of the chemical reactions and most of the setting expansion are considered to have been completed and the investment has sufficient strength to withstand the thermal shock.[11]

The difference in group 2 and group 3 can be due to the influence of the recast alloy.

Various authors have studied the effect of recast base metal alloys on crown's marginal accuracy and found maximum marginal fitness in 100% new alloy castings and minimum fitness in 100% reused alloy castings. While the marginal fit with 50%new and 50% reused alloy was less than 100% new alloy but was clinically acceptable.

Similar studies were carried out by Lopez et al; they stated that marginal fitness of new alloy was more ideal than that of recasted alloy. Lopez declared that oxidization, vaporization and porosity are all responsible for the difference between recasted and new alloy marginal gap**.**[21]

All the studies carried out earlier, state that even though the marginal accuracy of the castings made with using recast alloy in different percentages is less than new alloy, they can still be used with 50% reused alloy as the marginal loss is within the maximum tolerance limit.

In the present study total mean marginal discrepancy was 88.43±14.11 for group 1, 92.66±13.80 for group 2 and 96.29±8.63 for group 3. The mean marginal difference between group 1 and group 2 was 4.23, between group 1 and group 3 was 7.86 and group 2 and group 3 was 3.63. The mean marginal loss of group 1 with their respective wax pattern was 79.02, group 2 was 84.52 and group 3 was 87.80.

The marginal discrepancy between the groups with different percentages was higher than previous studies conducted on recast alloy mainly due to the fact that earlier studies were conducted using high noble alloys. The main reason for this variation may be the difference in the casting shrinkage of the gold based and Ni-Cr alloys. The other probable reasons for these results might be the combined effect of (1) The marginal discrepancy of the wax patterns (2) No die spacer was used therefore the castings bind more on the axial walls of the metal die.[20, 22] The furnace burnout is thought to provide mold expansion and wax elimination. In case of accelerated casting technique a shorter burnout time yields inadequate mold expansion leading to under-sized castings.[14] The increasing percentage of recast alloy also might have affected the marginal fit.

In this study 120 µ was considered as the maximum clinically acceptable marginal gap for the castings.

Conclusion:

Under the conditions of this study the following conclusions were drawn:

1. The marginal accuracy of the full coverage single crowns fabricated by Accelerated casting technique using 100% new alloy was greater than 25% and 50% recast alloy.
2. The marginal accuracy of the full coverage single crowns fabricated by accelerated casting technique was statistically not significantly different in between either 2 of the 3 groups.
3. Clinically acceptable complete castings can be obtained with the accelerated casting

technique using recast alloy in varying percentage with new alloy.

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