Comparative Evaluation of Marginal Accuracy of Castings Fabricated By Conventional Casting Technique and Accelerated Casting Technique Using Nickel Chromium Alloy and Cobalt Chromium Alloy-An In-Vitro Study

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Abstract

Background: Conventional casting technique is time consuming when compared to accelerated casting technique. In this study, marginal accuracy of casting fabricated using accelerated and conventional casting technique using nickel chromium and cobalt chromium alloy was compared.

Materials and Methods: 60 patterns were fabricated and the marginal discrepancy between the die and patterns were measured using optical stereomicroscope. 30 wax patterns were used for conventional casting and rest for accelerated casting. A Nickel-Chromium alloy and Cobalt-Chromium alloy was used for the casting. The castings were measured for marginal discrepancies and compared.

Results: Castings fabricated by Conventional casting technique using Cobalt-Chromium alloy showed less vertical marginal discrepancy than the castings fabricated by Conventional casting technique using Nickel-Chromium alloys. The values were statistically significant.

Conclusion: Conventional casting technique using Cobalt-Chromium alloy produced better marginal accuracy when compared to Conventional casting technique using Nickel-Chromium alloy. The vertical marginal discrepancy produced by the Accelerated casting technique using Nickel-Chromium and Cobalt-Chromium alloy was well within the maximum clinical tolerance limits.

Clinical Implication: Accelerated casting technique can be used to save lab time to fabricate clinical crowns with acceptable vertical marginal discrepancy and use of Cobalt-Chromium alloy for the patient that have Nickel-Chromium allergy.

Keywords: Accelerated casting, conventional casting, marginal accuracy, phosphate-bonded investment.
Introduction

Although, the “Lost wax” technique has been used since ancient times, it has become a common practice in dentistry after it was introduce by William H. Taggart in 1907.¹

Conventional casting technique which is routinely used in dentistry usually requires at least 1 h for the investment to set, followed by a one or two stage wax elimination procedure before casting is done. This procedure is time consuming and requires approximately 2-4 for completion.¹⁻³

Accelerated casting technique has been reported to achieve similar quality results in significantly less time, namely in 30-40 min for the fabrication of High noble alloys crowns.¹⁻³

Nickel alloy contribute to the chronic inflammatory reactions and also cause allergy in some patients these risks can be minimized by selecting alloys with relatively low Ni² release. Dental interest in Co-Cr has increased due to its low price and is considered as good alternative to nickel chromium alloy.⁴

This study evaluated the marginal accuracy of full coverage single crown made with an accelerated and conventional casting technique that uses phosphate bonded investment material and a Nickel-Chromium (Ni-Cr) and Cobalt-Chromium (Co-Cr) alloy.

Materials and Methods

The study was conducted in Department of Prosthodontics, Crown and Bridge and Implantology, Bharati Vidyapeeth Dental College and Hospital Pune.

A stainless steel die assembly was used to fabricate standardized wax patterns. The master die {figure1} simulated a crown preparation with 6-degree total axial wall taper. The axial height of the die and its occlusal diameter were 6mm and the finish line was a 90-degree shoulder, 1 mm with the width. Occlusal cross hairs were placed for precise wax pattern repositioning. the die could be accurately positioned in a stainless steel former {counter die} that had an opening in the centre 1 mm larger than the die in all dimensions {figure 1}.

Wax pattern {Bego, Germany} were fabricated on the master die by closing the counter die until the demarcated mark over the die to obtain a wax pattern of uniform thickness. the margins were readapted and divided into 4 groups with 15 wax patterns in each group.

- Group I : Ni-Cr copings fabricated by conventional casting technique
- Group II : Ni-Cr copings fabricated by accelerated casting technique
- Group III : Co-Cr copings fabricated by conventional casting technique
- Group IV : Co-Cr copings fabricated by accelerated casting technique

The wax patterns were spurred. Wax patterns were invested individually with individual casting rings lined with a ceramic ring liner. They were invested with bellasum {Bego, Germany} phosphate bonded investment {60g of powder to 16 ml of 100% mixing liquid}.

Group I and Group II: The investment was allowed to set for 2-3h. Then the casting ring was placed in a burnout furnace at room temperature and the temperature was raised to 250°C and maintained for 60 min. Thereafter the temperature was raised to 90°C and held for 30 min.

Group II and Group VI: The investment was allowed to set for 13-17 min, immediately the casting ring was placed in burnout furnace at a pre-heated temperature of 815°C for 15min.

After the completion of the burnout, the casting procedure was carried out in an induction-casting machine using Ni-Cr alloy (Wiron99, Bego, Germany) and Co-Cr alloy. The casting were recovered [figure 2], burs were used to remove the investment from the inner surface of the
casting such as a thin layer of investment was left behind sandblasting was done to remove the residual investment and oxide layer.

The completed casting were seated on the metal die under finger pressure [Figure 3]. The marginal discrepancy between the metal die and the castings were measured [table 1] on an optical stereo microscope at predetermined points using Pro-Plus software [Figure 4].

All measurements were executed by a single operator and the reading were tabulated and used for the statistical analysis (student’s unpaired t-test was used). The marginal accuracy of castings were compared with the conventional and Accelerated castings using Nickel and Chromium and Cobalt Chromium ally [Tables 1 and 2].

Table 1

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### Results

The castings fabricated by Cobalt-chromium alloy using conventional casting technique showed less vertical marginal discrepancy (131.17) than the castings fabricated by Nickel-Chromium alloy (191) using conventional casting technique (Group I < group III). The values were statistically significant (p-value < 0.05). The marginal discrepancy of the 15 castings fabricated by accelerated casting technique using nickel chromium alloy (group II) showed a mean value of 163.75µm. The marginal discrepancy of the 15 castings fabricated by accelerated casting technique using cobalt chromium alloy (Group IV) showed a mean value of 135.20 µm.

### Discussion

Factors affecting the success of an FPD are multiple and complex. Marginal integrity is one such factor which influences the longevity of the final prosthesis in the oral cavity. Clinical acceptability and longevity of cast restorations is related to marginal fit. This has been shown to be clinically significant to the periodontal health and the development of recurrent marginal caries. Clinically, a cast alloy crown can be regarded as a good fit if it has sufficient axial tolerance to allow seating and if its margin is congruent with the cavo-surface line angle of the tooth preparation as judged by visual and tactile examination.

The marginal fit of castings basically relies on precise tooth preparation, accurate impressions and precision during casting procedures. Schwartz et al cited defective margins are a frequent cause (11.3%) of unserviceable crowns and fixed partial dentures. Grasso et al reported that 30 to 40% of crown margins were inadequate, often because of poor marginal integrity. Recent studies continue to demonstrate high rates of marginal deficiencies and indicate that defective margins are responsible for over 10% of failed units.

The primary physical-chemical properties of base metal alloys include a lower density than gold alloys, a particularly useful feature in fabricating less bulky prostheses, and a modulus of elasticity that is nearly twice that of gold alloys, providing fixed and removable partial dentures with the advantage of maintaining rigidity with less bulk. These properties allow for improved esthetics and physiological contouring and the development of a suitable occlusion with less tooth structure reduction. More recently, improvement in alloy composition and development of new manufacturing techniques have optimized the use of these alloys and therefore were considered suitable for the present study. However nickel
Ni-Cr and Co-Cr castings using accelerated and conventional casting technique.

The marginal discrepancy was observed using Stereo Microscope and an Image analysis software

**The statistical analysis is as follows:-**

1. There was no significant difference between conventional and accelerated casting technique fabricated by nickel chromium alloy as unpaired t-test demonstrated p-value >0.05.
2. There was no significant difference between conventional and accelerated casting technique fabricated by cobalt chromium alloy as unpaired t-test demonstrated p-value >0.05.
3. There was significant difference between nickel chromium and cobalt chromium alloy using conventional casting technique as unpaired t-test demonstrated p-value <0.05.
4. There was no significant difference between nickel chromium and cobalt chromium alloy using accelerated casting technique as unpaired t-test demonstrated p-value >0.05.

These results are not in line with a study conducted by Katta Sridhar Chowdary where in the marginal accuracy of the Ni-Cr was found better than that of Co-Cr. A similar study was conducted by Pavan Kumar Tannamala et.al, they compared the conventional and accelerated casting techniques using Ni-Cr alloy and found that a statistically significant difference was found between both the techniques but the mean marginal discrepancy was within clinically permissible limits.

This difference in the marginal discrepancy in this study and the study conducted by Pavan Kumar maybe due to the use of beryllium free Ni-Cr alloy in this study. As noted by David Duncan Ni-Cr alloys containing beryllium appeared to have a lower casting temperature, less casting
shrinkage, better casting accuracy and less variation of results than Ni-Cr alloys not containing beryllium\textsuperscript{12}.

A study by Bronson MR et,al checked the clinical acceptability of crown margins versus marginal gaps. The gaps ranged from 40µm-615 µm thus the marginal discrepancy found in this study of all the groups is well below the range of marginal gap suggested by Bronson. On reviewing the literature no studies were found wherein Co-Cr alloy was used with accelerated casting technique.\textsuperscript{13}

Following are the limitations of this study:

1. Prior to casting, wax pattern were not evaluated for discrepancy under microscope, as discrepancy in wax pattern can ultimately replicate in the final copings.
2. The study was conducted using stone die that had even margin and the wax pattern fabricated over the stone die was also of even thickness along with even margin. But in long term clinical practice, it is very difficult to obtain such even margin on tooth and even thickness of wax pattern over die that may affect the final accuracy of the casting.
3. Polishing and finishing of the casting was done manually which may also create some discrepancy in the casting.
4. This study was conducted over a period and environmental temperature may also have influence on the fabricated wax pattern.

Conclusion

The order of discrepancy values of marginal gap of the cast copings in the study is as follows:-

A. Minimum marginal gap- cobalt chromium copings using conventional casting technique (Group III) \textbf{131.17 µm}.

B. Maximum marginal gap- nickel chromium copings using conventional casting technique (Group I) \textbf{191µm}.

The comparative statistical analysis of maximum vertical marginal discrepancy was seen in Group\textbf{I} and minimum seen in Group III.

References


Legends Figures

Figure 1: Master Die with Counter Die

Figure 2: Recovered Group I, II, III and IV

Figure 3: Castings Were Seated On Die

Figure 4: Marginal Discrepancy Checked Under Stereo-Microscope - Casting With Sprue Attached