Evaluation of Marginal Gap of Ni-Cr Based Base Metal Alloys and the Clinical Acceptability of Single Castings Invested in Phosphate Bonded Investment with the Use of Conventional and Accelerated Casting Techniques An In-Vitro Study

S. Parithimar Kalaignan,* N. Shanmuga Nathan,** Syed Ali Peeran,***

Abstract:

Objectives: This Study evaluated the marginal gap of Ni-Cr based base metal alloys (RemaniumCse &Wiron 99) and the clinical acceptability of single castings invested in phosphate bonded investment with the use of conventional and accelerated casting techniques.

Materials and methods : Forty individual stone casts were poured from impression made from master die .Conventional and accelerated method of investing and casting were followed .twenty casts were used in each of the groups .Each casting and its respective stone dies were measured with a stereomicroscope equipped with reticule scale at 4X magnification.

Results: Measurements revealed that, mean values for the marginal gap of cast metal crowns casted with accelerated casting technique were 34.5 microns for Remanium CSe and 43.5 microns for wiron 99 and marginal gap of cast metal crowns casted with conventional casting technique mean values were 34 microns for Remanium CSe and 39 microns for wiron 99 base metal alloys. All marginal gap measurements were within the range of clinical acceptability. For the marginal gap, cast metal crowns fabricated with the accelerated casting technique were not significantly ($p > 0.05$) different from those fabricated with the conventional technique.

Conclusion: the accelerated casting technique described in this study could be a vital alternative to conventional casting technique.

Introduction

Many materials and numerous methods have been suggested for fabrication of dowel and cores, complete crowns, fixed partial dentures. The conventional investing and casting procedures for these restorations call for a minimum of 1 hr bench set for investment followed by a 1or 2 stage burn out procedure before casting. The whole process requires 2 to 4 hr for completion. According to the accelerated casting technique the dowel and cores1 and the complete crowns can be invested and cast in 30 min with comparable results.

The first published attempt to accelerate the lost wax technique with use of phosphate bonded investment for a complete crown was made in 1988 by MARZOUK & KERBY[2] who recognized the importance of investing temperature. Murakami *et al*[3] studied the rapid burnout technique with gypsum-bonded investments to examine surface aspects and fit of complete crowns an d noted that the setting process was considered in progress at 30 minutes when the mold was placed in the preheated oven. They stated that because of this step, less expansion had occurred and was probably responsible for increased marginal gaps. Materials with greater setting expansion have demonstrated better marginal fit of crowns.

Accelerated casting technique can be advocated for routine use only if the resulting castings fulfill important clinical parameters. The marginal integrity of a restoration is one of the critical factor to achieve long term clinical success Achieving perfect fit is the prime objective for cast metal restoration and in cases where there is inadequate marginal fit of the cemented restoration, a thin line of cementing is exposed to action of saliva and oral fluids this inaccuracy in the margins promote marginal leakage and initiation of secondary caries.

*) Senior Lecturer, Dept of prosthodontics. Sri Ramachandra dental college. Sri Ramachandra University.Chennai.
**) Reader, Dept. of prosthodontics, Sri Ramachandra dental college, Sri Ramachandra University. Chennai.
***) P.G student, Dept of Prosthodontics, Vinayaka Missions University, Salem.

Accelerated casting technique have been reported to achieve similar quality in less period of time .These technique mainly used for cast dowel and core restorations .So far no study has been conducted with enough data to determine the marginal gap of single cast metal crown using accelerated casting technique.

Aims and Objectives:

1. To evaluate the marginal gap of cast metal crowns with Ni-Cr based base metal alloys (Remanium CSe and Wiron 99) using conventional casting technique.
2. To evaluate the marginal gap of cast metal crowns with Ni-Cr based base metal alloys (Remanium CSe and Wiron 99) using accelerated casting technique.
3. To compare and evaluate the marginal gap of cast metal crowns with Ni-Cr based base metal alloys (Remanium CSe and Wiron 99) using conventional and accelerated casting technique.

Review of literature:

Many frs affect the overall acceptability of a cast restoration and many methods and techniques are used to improve it. A cast restoration must seat accurately on the tooth, exhibit a minimum cement margin, be adequately retained, and restore or improve function and esthetics. Marginal adaptation[4] (fit) is considered to be a primary and significant factor in the prevention of secondary caries and is an important indicator of the overall acceptability of the cast restoration.

Determinants Of The Marginal Adaptation Of Cast Restorations

Tooth preparation:

Geometry of the tooth preparation, including type of finish line and degree of taper, is an important factor in obtaining close marginal adaptation. Optimum convergence for retention form of preparations of 2 degrees to 7 degrees has been advocated. Taper angles of less than 10 degrees restricted flow of cement at occluso-axial line angles. The more closely the casting is adapted to the tooth, the more difficult it is for the cement to escape from between the tooth and the casting.

Certain finish lines facilitate escape of cement early in the cementation process. Several studies, agree that featheredge margins produce the best seal compared with 45-degree and 90-degree margins, even though there may be more occlusal displacement of the casting. Castings on preparations with shoulders seat more completely, but geometrically the marginal seal is poorer.

Dootz et al[5] (1965) measured the compressive strength of three phosphate investment, both at room temperature, after two hours setting, and at their usual burn out temperature of 928 °C. The fired compressive strength of one was unchanged, while for other two it increased by factor of 2.4 and 2.7. Christensen[6] (1966) studied on marginal fit of gold inlay castings. Direct wax patterns were carved and type B gold alloy castings were made for each tooth. The marginal fit of the inlay was measured microscopically before finishing procedures .He found that the least acceptable, visually accessible margin was computed from a linear regression prediction formula to be open 39 microns the range of opening of 40 barely of clinically acceptable margins was from 2 to 51 microns.

Jenkins and Phillips[7] (1971) studied the effect of different investments on the marginal fit of inlays and crowns. They found significant differences in the marginal gaps of inlays depending on which investment was used, but noted no overall significant differences. Complete crowns exhibited no significant differences in marginal discrepancies regardless of the investment or technique used

Lacy et al[8] (1983) investigated the related effects of (1) mixing rate (2) ring liner position, and (3) storage conditions on the setting expansion of both gypsum-bonded and phosphate bonded investment molds; and subsequently to correlate casting size with measured expansion data. They concluded that position and extent of ring liners, rates of mixing, and conditions of storage may be even more significant in determining ultimate casting size than clinically accepted factors such as liquid/powder ratios or numbers of ring liners. The dynamic nature of setting expansion within the first 60 minutes after mixing suggests that consistent results demand waiting at least that long prior to burnout. If molds are to be stored overnight maximum dimensional stability is probably ensured by keeping them in 100% relative humidity, particularly if CaSO4 $2H_20$-containing gypsum-bonded investments are used.

Konstantoulakis et al[9] (1998) studied the Marginal discrepancy and surface roughness of crown made with an accelerated casting technique that uses a four phosphate bonded investments and high noble ceramic alloys. Crowns fabricated with this accelerated casting

technique were not significantly different from those fabricated with conventional technique.

Schilling et al[10] (1999) studied the marginal gap of crowns made with a phosphate bonded investment and accelerated casting technique. They observed that marginal gap measurement recorded on the perpendicular and a 25 degree tilt of the stone die showed no statistically significant difference between conventional and accelerator casting technique.

Blackman[11] (2000) investigated the effect of 2 rapid mold preparation schedules on full crown castings by comparing size, margin sharpness, and surface roughness. Three groups of 1O crowns were cast with a type III gold alloy. All crowns were nominally identical, only their mold preparation schedules differed. Two groups used accelerated schedules; the third group was cast using a conventional schedule. He found that measured crown diameters, indexing size for the 3 groups, were not significantly different. Crowns made with the conventional schedule had greater surface roughness, and better margin sharpness or length.Crowns were successfully cast using accelerated mold preparation techniques and considerable time saved, but a small loss of margin length or fineness was observed.

Yang et al[12] (2007) did a study on the setting expansion, compressive strength, thermal expansion, and surface roughness of the 2 phosphate bonded investments (Maruvest-Speed (Megadental) and Z4 C&B (Neirynck and Vogt]). Two different heating methods the quick-heating method (QHM) and conventional heating method (CHM)-were used with the investments. The dimensional accuracy and surface roughness of the nickel-chromium alloy castings obtained from the investments were also examined. They reported that the Maruvest-Speed investment had a significantly greater setting expansion (2.2%) than the Z4 investment (1.1%) after a 30-minute setting time. The fired strength of both investments was greater with QHM (21.2 to 27.7 MPa) than with CHM (13.8 to 17.9 MPa). The thermal expansion of the Maruvest-Speed investment and Z4 with QHM was 1.7% and 1.4%, respectively. There was no significant difference in surface roughness of the castings between samples treated with QHM and CHM. The dimensional accuracy of the castings was larger in length and slightly deformed in bend. They concluded that the characteristics of the 2 commercial quick-heating phosphate-bonded investments for the accelerated casting technique may be acceptable.

Materials and Methods:

Materials used in fabrication of wax pattern:

Custom tray

Poly vinyl silicone impression material, Reprosil, (Dentsply, USA).

Type IV Dental Stone

Wax Separator—Sigmadent, India.

Pattern Wax ---Hard casting wax sticks (Harvard, Blauwachs, Germany).

Magnifying lens.

Materials used in casting procedure

Sprue material – wax wire round –hard, diameter 3mm, (Bego, Germany)

Casting ring –diameter1-1/2'', length 1-9/16 '', (whip mix corporation, USA).

Casting liner –cellulose, asbestos substitute, (whip mix corporation, USA).

Crucible former –1- 3/4'' diameter, (whip mix corporation, USA).

Surface tension reducing agent –Smoothex, (whip mix corporation, USA)

Phosphate bonded investment –Bellasun (Bego, Germany).

Vibrator -- (Degussa).

Quartz crucible—ASEG, A100, 481

Burnout furnace –kavo, EWL, Typ 5630.

Casting ring forceps.

Casting machine –Induction casting machine.Galoni, Italy[13].

Ultra sonic cleaner –Sonorex.

Nickel chromium alloys

Wiron 99 and Remanium CSE[14,15,16]

Materials Used For Measurements

Stereomicroscope –Labomed, CZM4

Special Type of Eye Piece Equipped With Reticule Scale

Custom made caliper device.

Dimensions of master die[9]:
The dimensions of Brass Master Die Assembly are as follows:
The master die simulates a crown preparation with an axial wall taper 10 degree, the height of the die and its occlusal diameter is 6 mm and the finish line is a shoulder of 1mm width, angled at 90 degree.

Duplication of master die:
Master die single tooth preparation to receive a metal crown was duplicated using poly vinyl siloxane impression material.

Wax pattern fabrication:
The brass master die was lubricated with wax separator and wax poured on top of the former (brass assembly).The die former assembly was held together for 1 minute and then immersed in room temperature water for 3 minutes.

The die was then separated from the former assembly; all excess wax was removed from margin area followed by the wax pattern transferred to the stone die model. The intaligo surface of the each wax pattern was carefully inspected with magnifying lens to ensure it was smooth and free of defects. The wax pattern was repositioned on its stone die model and the marginal refinement of the wax pattern was completed

Investing Procedure:
To minimize distortion, each pattern was invested immediately .Casting rings were lined with non overlapping asbestos substitute ring liner, which was maintained 3mm below the top of the ring
Recommended bench set time 60 minutes for conventional and 15 minutes for accelerated technique.

Casting technique	Investment material	Bench set time
Conventional	Phosphate bonded investment (Bellasun)	60 minutes
Accelerated		15 minutes

Burn out Temperature:

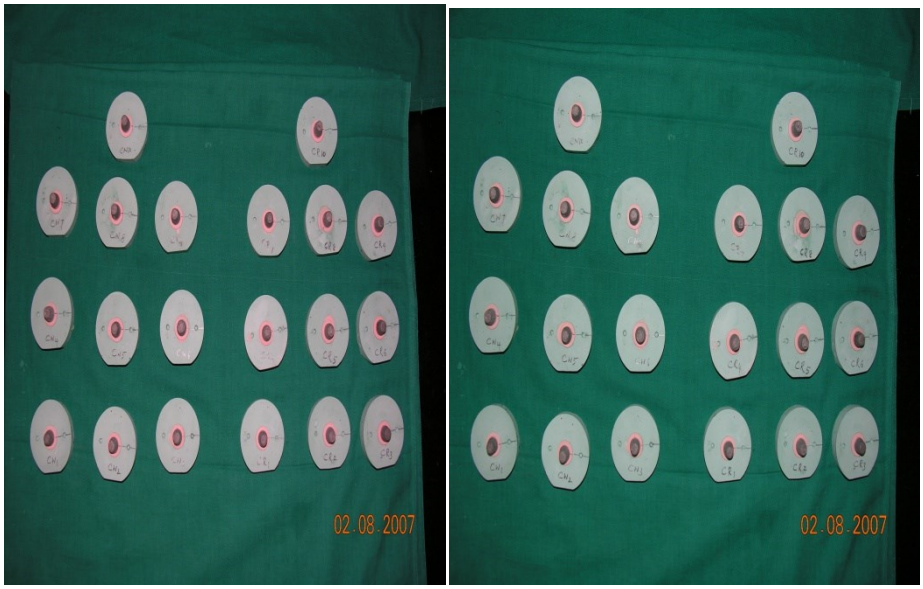
Casting Techniques	Burn out temperature
Conventional (Based on manufactures instructions)	900 °C for 60 minutes (increasing gradually)
Accelerated (Based on konstantoulakis Study)	820°C for 15 minutes (Preheated burnout furnace)

CASTINGS:
All casting procedures were performed using induction casting machine.
The castings were bench cooled to room temperature. After removal from the investment, all castings were carefully sand blasted with 250 micro meter aluminum oxide at 30 psi pressure from 5 cm distance.

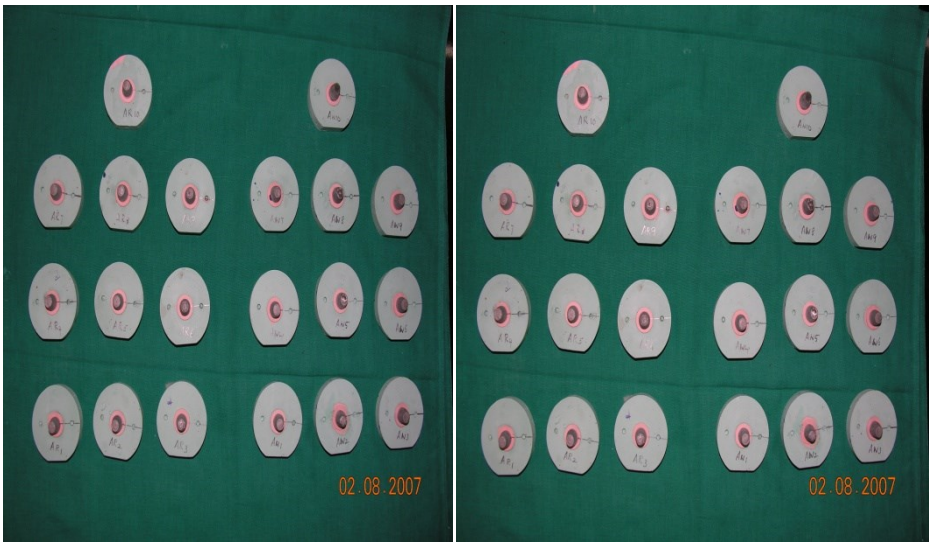
Measurement of Marginal Gap:

Each casting was seated on its respective stone die and subjected to a constant load on the occlusal surface by using custom made caliper, to maintain the seating pressure between the casting and the stone dies during travelling stereo microscopic measurements. Grooves on the occlusal surface of the die to prevented rotation and ensured seating of the crown at the same position as the wax pattern.

The distance between finish line of the stone die model and edge of the castings were recorded by using stereomicroscope equipped with reticule scale at 4x magnification in perpendicular line of view.



Conventional casting samples (Remanium Cse &wiron99)



Accelerated casting samples (Remanium Cse&Wiron 99)

Observations and Results:

Non Parametric or Distribution –Free Statistical Tests

Mann –Whitney U Test

This the most powerful test for the uncorrelated data.

Formula Used For Mann –Whitney U Test:

$$Z = \frac{U - E[U]}{\sigma U}$$

U = Minimum $[U_1\ U_2]$

$$U_1 = n_1 n_2 + n_1 \frac{[n_1+1]}{2} - R_1$$

$$U_2 = n_1 n_2 + n_2 \frac{[n_2+1]}{2} - R_2$$

R_1 = Sum of the ranks of the 1st group

R_2 = Sum of the ranks of the 2nd group

TABLE I : Measurements Of Marginal Gap Of Cast Metal With Ni-Cr based Base Metal Alloys (Remanium CSe And Wiron 99) Using Conventional Casting Technique

SAMPLE NO	REMANIUM CSe (micro meters)	WIRON 99 (micro meters)
1	30	20
2	40	35
3	55	45
4	35	30
5	20	40
6	35	50
7	25	60
8	40	25
9	30	40
10	30	45

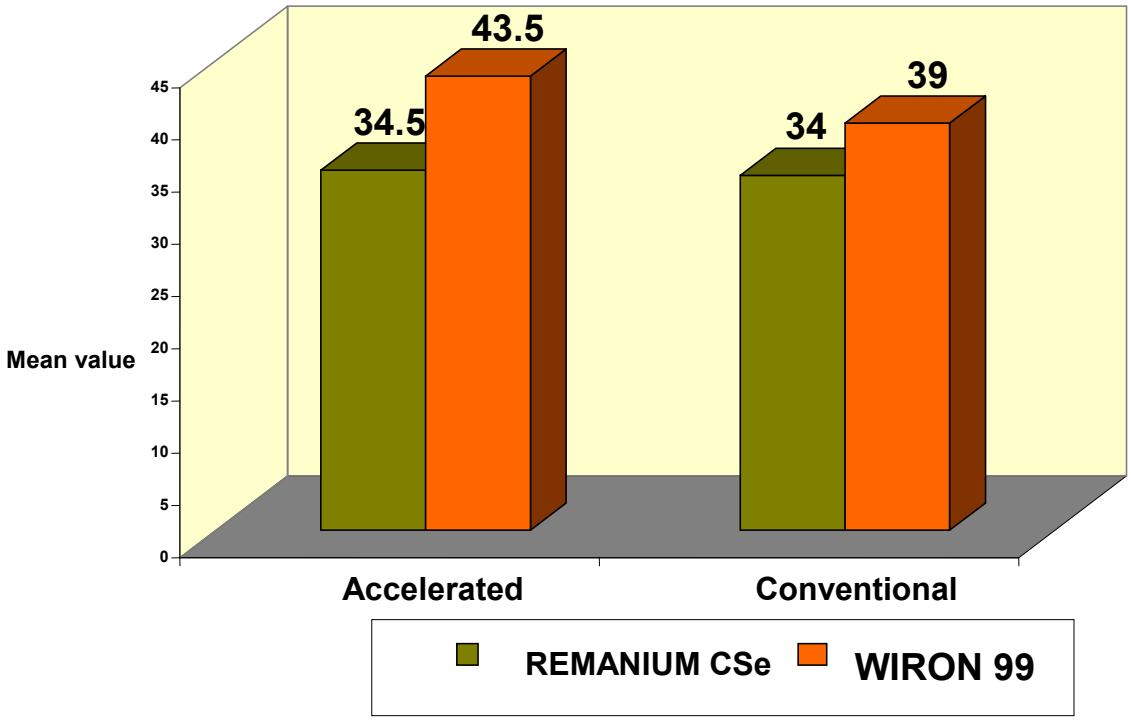
TABLE II: Measurements Of Marginal Gap of Cast Metal with Ni-Cr based Base Metal Alloys (Remanium CSe And Wiron 99) Using Accelerated Casting Technique

SAMPLE NO	REMANIUM CSe (micro meters)	WIRON 99 (micro meters)
1	40	50
2	30	30
3	20	30
4	35	60
5	40	45
6	70	40
7	20	35
8	25	60
9	30	35
10	35	50

Table III: shows the mean values, standard deviation, Z value, p value and significance level of Ni-Cr (wiron 99 &Remanium CSe) base metal casting alloy, using accelerated and conventional casting techniques

Group statistics

Group	Base metal alloy	N	Mean value	Standard deviation	Z Mann – Whitney U test
Accelerated Casting	Wiron 99	10	43.5000	11.31616	1.75700
	Remanium CSe	10	34.5000	14.42413	p = .079 ns
Conventional Casting	Wiron 99	10	39.0000	11.97219	1.10700
	Remanium CSe	10	34.0000	9.66092	p = .28 ns



Graph ; Shows the Comparison of mean (in micrometers) of Ni- Cr base metal alloys between Conventional and Accelerated Casting Groups

In our study results shown that, mean values for the marginal gap of cast metal crowns casted with accelerated casting technique were 34.5 microns for Remanium CSe and 43.5 microns for wiron 99 and marginal gap of cast metal crowns casted with conventional casting technique mean values were 34 microns for Remanium CSe and 39 microns for wiron 99 base metal alloy.It revealed that Remanium CSe base metal alloy performed more efficient in marginal fit than wiron 99 base metal alloy in both the casting techniques.All marginal gap measurements were within the range of clinical acceptability.For the marginal gap, cast metal crowns fabricated with the accelerated casting technique were not significantly ($p > 0.05$) different from those fabricated with the conventional technique.

Discussion:

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. Although no scientific explanation has been offered, when the investment reaches its maximum exothermic temperature setting reaction temperature, most of the chemical reactions and most of the setting expansion is considered to have been completed and the investment has the sufficient strength to withstand the thermal shock. It has been observed that phosphate bonded investment (Bellasun) reaches peak setting reaction temperature approximately within 15 minutes by using finger touch method .Based on this observation, (bellasun) phosphate bonded investment selected for accelerated casting technique in this study.

Konstantoulakis et al [1998) studied the Marginal discrepancy and surface roughness of crown made with an accelerated casting technique by using four phosphate bonded investments and high noble ceramic alloys. Crowns fabricated with this accelerated casting technique were not significantly different from those fabricated with conventional technique. In the above study observations pointed out the mold damage occurred in 50%of the accelerated casting groups, but did not occur on the surfaces of the castings, it was hypothesized that the fracture was caused by method of investing (Vac–U–spat system), which may have created a more dense investment with decreased porosity making it more difficult for gases to escape and this more likely for an explosion to occur. In our study, to prevent the mold damage, vaccum mixing unit was not used for accelerated casting group.

The purpose of this study was to measure the marginal gap and clinical acceptability of single castings with Ni-Cr based base metal alloys (Wiron 99 and RemaniumCSe) Invested in Phosphate Bonded Investment by Using Conventional and accelerated casting technique methods. The new accelerated casting technique though it reduces the time consumption, its reliability and other aspects has yet to be established for appreciable clinical success.

In this study, individual stone dies were used which were prepared from the brass master die. The marginal fit of the crown was examined on the stone die to simulate the cast fit of the crown. In the clinical situation, the fit of a crown is also influenced by several factors other than casting procedures such as impression materials used and their techniques and the process for making a working die.

Therefore in this study stone die was used to clarify the sole effect of the heating process of the mold on the quality of the casting .Clinically adequate fit of a crown must first be obtained on the working die before the crown seated on the prepared tooth .Then clinical seating could be extrapolated from the results of our study.However constant seating pressure was applied with a custom made caliper during measurement procedure so that it closely resembled the clinical situation.

In our study results shown that, mean values for the marginal gap of cast metal crowns casted with accelerated casting technique were 34.5 microns for Remanium CSe and 43.5 microns for wiron 99 and marginal gap of cast metal crowns casted with conventional casting technique mean values were 34 microns for Remanium CSe and 39 microns for wiron 99 base metal alloy. It revealed that Remanium CSe base metal alloy performed more efficient in marginal fit than wiron 99 base metal alloy in both the casting techniques.Statistical analysis showed that difference in marginal gap of cast metal crown made with accelerated casting technique did not differ from those of conventional casting technique.

Clinical Implications:

Significant amount of time can be saved with accelerated casting technique described in this study. Accurate casting can be made in approximately 30 minutes instead of 2 to 4 hours with out sacrificing marginal integrity. This accelerated casting method provides the

dentist, patient, and dental laboratory technician with a time saving, cost effective technique for the fabrication of single unit castings for metal / ceramic crowns.

Summary and Conclusion:

A total of forty individual stone casts were poured from poly vinyl siloxane impressions made from a master die. Conventional and accelerated methods of investing, bench set time, burnout temperature and casting were followed in fabrication of forty single unit castings. Individual stone die was used for each wax pattern. Each casting and stone die were measured with a stereomicroscope equipped with reticule scale at 4X magnification.

Under the condition of this study, the following conclusions were drawn:

1. Marginal gap for castings made with Ni-Cr based base metal alloys (Remanium CSe and Wiron 99) showed no statistical difference between the two groups by using conventional casting technique.
2. Marginal gap for castings made with Ni-Cr based base metal alloys (Remanium CSe and Wiron 99) showed no statistical difference between the two groups by using accelerating casting technique.
3. Marginal gap for castings made with an accelerated casting technique showed no statistical difference when compared with a conventional casting group.
4. The methods used for accelerated casting technique are technique sensitive. Minor variations in the procedures can cause casting defects such as nodules, fins and porosity.
5. Clinically acceptable complete castings can be obtained with the phosphate bonded (bellasun) investment by using accelerated casting technique if optimum peak setting reaction temperature time is selected for the investment material.
6. The accelerated casting technique offers a cost effective and time saving method by which single unit castings for metal / metal ceramic crowns can be fabricated.

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