Original Article

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Dentistry Section

Effects of Casting Methods over the Composition Stability of the Dental Casting Alloy

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ABSTRACT

Introduction: Alloys with high nickel content have been increasingly used for dental prostheses. The dental casting machines are regularly used to make dental restorations. The effects of the casting of the base metal alloys using acetylene-oxygen flame casting machine and induction casting machine has not much been studied.

Aim: To estimate nickel, chromium, cobalt, and molybdenum metals from as-received dental casting alloy of three different brands and to estimate metals from these alloys after fabrication of crown using acetylene-oxygen flame casting machine and induction casting machine.

Materials and Methods: This in-vitro comparative study was conducted in the Department of Prosthodontics at School of Dental Sciences, KIMSDU, Karad, Maharashtra, India. Total of 15 crowns were fabricated using acetylene-oxygen flame casting machine and 15 crowns by induction casting machine from three different brands of Dental Casting Alloys (DCA) by lost wax technique. Elemental estimation was done for the as-received pellets and for the crowns fabricated by both methods using X-ray Florescence spectrometry (XRF). Unpaired t-test was used for data analysis.

Results: Nickel (Ni), chromium (Cr) and molybdenum (Mo) levels in crowns fabricated by both acetylene-oxygen flame casting and Induction casting technique were significantly decreased (Ni: -2.01% to -5.14%, Cr:-7.35% to -29.51% and Mo: -15.70% to -95.94%) in all brands of dental casting alloys. Cobalt level was not detected in all three brands of fabricated crowns by XRF by either of the casting methods.

Conclusion: These observations indicate that the elemental composition of the fabricated crowns is decreased as compared to that of as-recieved crowns, which could be due to the burnout of some amount of elements during casting.

Keywords: Biocompatibility, Corrosion, Fabricated crowns, Leaching

INTRODUCTION

Casting alloys alternatives which are less expensive and readily accessible are being researched consistently. Various dental casting alloy systems has been developed in dentistry for dental restorations. The nickel, chromium, cobalt, and molybdenum metals are mainly present in the Dental Casting Alloy (DCA) and different brands of DCA are available in the market [1].

Base metal alloys, such as Nickel-Chromium (Ni-Cr) and Cobalt-Chromium (Co-Cr), are being regularly used in the fabrication of fixed and removable partial denture frameworks since 1929 [2-5]. These alloys have replaced gold alloys due to improved mechanical and economic properties. The advantages of base metal alloys over gold alloys are:

1. Lower density of base metal alloys, which helps in fabricating a less bulky prosthesis.
2. Higher modulus of elasticity, which helps in maintaining the rigidity of the prosthesis.
3. Conservative tooth preparation in sufficient [6].

The main drawback of the base metal alloys is the difficulty in grinding, finishing and polishing the fabricated prosthesis [7,8]. The surface smoothness of fabricated prosthesis is of great importance in avoiding adherence of micro-organisms. The attachment of the microorganisms to rough framework surfaces leads to the increase in the incidence of oral diseases and the hastening of biocorrosion by providing retentive niches [9,10].

The process of fabrication of crowns undergoes the casting procedure, which has a risk of impurities getting incorporated in the alloys, resulting in different compositions of the alloy [11]. This occurs either from the material transformation during the casting procedure or from the inclusion of residual metals from previous work. Furthermore, some laboratories recast the sprues by adding new alloy pellets [12]. Altogether, these factors might influence the corrosion of the final product, leading to different corrosion properties from what the manufacturer claimed. The process of fabrication and polishing of DCA may alter the percentage of the metal [11]. There are no studies that have reported the influence of casting methods on the composition of the alloy, which in turn would affect the corrosion of the alloy. Hence, the present study was aimed to assess the composition of three base metal alloys, submitted to different casting techniques, to determine the influence of casting methods on composition after casting and compared to the as-received metal pellet.

MATERIALS AND METHODS

This in-vitro comparative study was conducted in the Department of Prosthodontics at School of Dental Sciences, KIMSDU, Karad, Maharashtra, India. The ethical clearance was obtained from the Institutional Ethical Committee [KIMSDU/IEC01/2018]. A total of 30 crowns were fabricated from three different brands of dental casting alloys and two different casting techniques. Also, 15 as-received pellets from three different brands were selected as control.

Inclusion and Exclusion critera: The completely casted crowns without any casting defects were included in the study. Any of the incompletely casted crowns or crowns with defects was excluded from the study.

Three brands of dental casting alloys having different composition was selected based on the composition and use.

- Brand I: Ni-Cr alloys contained (72.8%-Ni, 4.9%-Cr, 12.3%-Cu, 10%-others),
- Brand II: Ni-Cr alloys contained (74.7% -Ni ,4.8%-Cr, 13%-Cu, 7%-others)

- Brand III: Ni-Cr alloys contained (65%-Ni, 22.5%-Cr, 9.5%-Mo, 1%-No, 1%-Si, 0.5%-Fe, 0.5%-Ce, 0.02%-C).

Sample size calculation: The sample size of study groups for in-vitro study was calculated by using Mean and SD of Ni, Cr, Co, and Mo leaching level as per earlier study [13] and using the formula:

$$n = \frac{4SD^2}{(mean \times \in)^2}$$

SD is Standard deviation, M is mean, and $\in$ is precision=3%

As per 95% confidence interval and 90% power of earlier studies maximum sample size were five each group [13].

Five samples of each DCA pellets were selected as a standardising procedure and metals present in these three different brands DCA pellets were estimated by using the X-ray Florescence (XRF) spectrophotometers (Niton XL2 plus; Thermo Scientific). In XRF, X-rays are produced by an X-ray tube to irradiate the specimen. The elements present in the specimen emit fluorescent X-ray radiation with discrete energies according to their characteristic. The different energy corresponds to different colours. By measuring the energies of the emitted radiation of the sample, the elements present were determined. By measuring the intensities of the emitted energies (colours) the amount of each element present in the specimen was determined [14].

The selected pellets were used to fabricate the crowns using:

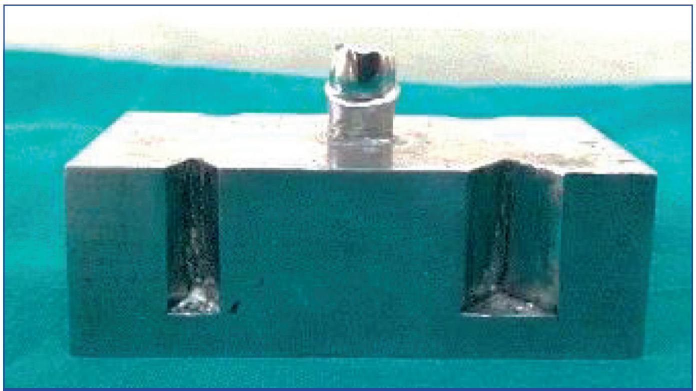
- **Acetylene-oxygen flame casting method:** 15 crowns fabricated (n=5 of each brand).
- **Induction casting methods:** 15 crowns fabricated (n=5 for each brand).

Study Procedure

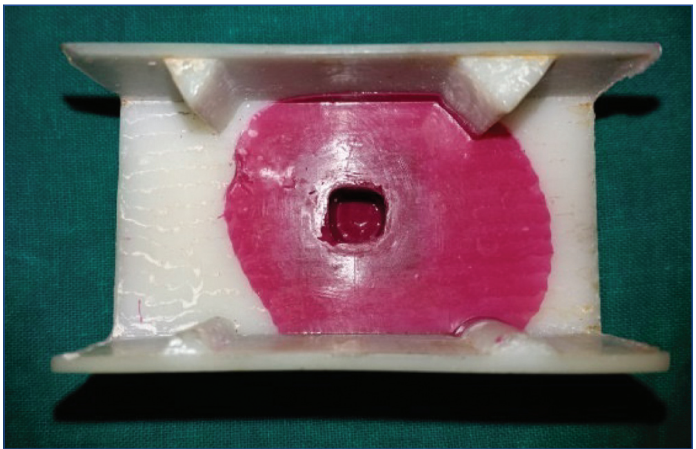
An Ivorine mandibular first molar was prepared using diamond points for receiving full veneer metal restorations with chamfer finish line [Table/Fig-1]. The prepared ivorine teeth were scanned using 3M Lava Optical Scanner and contra spray. Scanned images were exported to STL Format. The Design in STL Format was imported into the EOS plastic laser sintering system for milling, chrome cobalt (SP2:BEGO) models. The model so prepared were welded to a metal base, which was fabricated in mild steel.The base had specific orientation grooves that served for orientation of custom tray for impression making [Table/Fig-2].

[Table/Fig-1]: Tooth preparation on ivorine mandibular first molars.

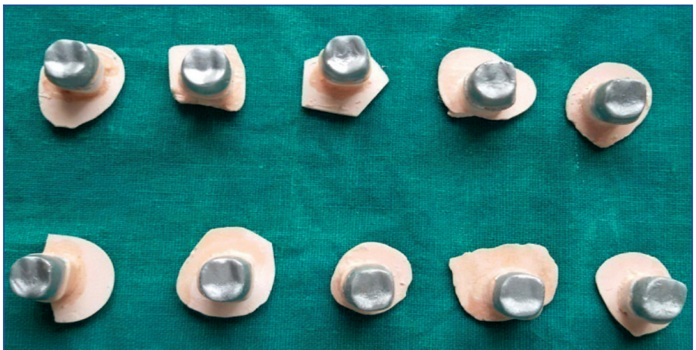
A total of 30 impressions were made to fabricate 30 samples of dies and were poured in Type IV Gypsum (Kalrock-Kalabhai Karso, Mumbai Pvt. Ltd.) according to manufactures instructions [Table/Fig-3,4]. Wax patterns were fabricated on these dies [Table/Fig-5]. The casting was carried out using lost wax technique. Three brands of DCA were tested based on their composition, price and frequancy of use.



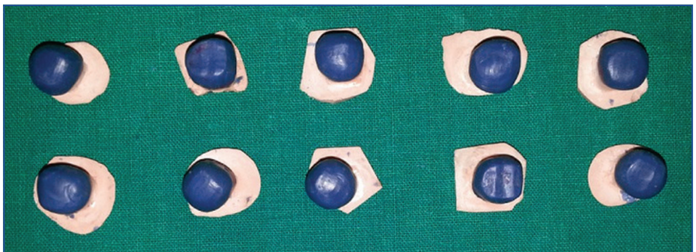
[Table/Fig-2]: Milled model welded to metal base.



[Table/Fig-3]: Impression over the custom tray.



[Table/Fig-4]: Fabricated dies coated with die spacer.



[Table/Fig-5]: Wax pattern fabricated over the dies.

They were grouped into

Group 1: Ni-Cr alloy casted in acetylene-oxygen flame casting machine (n=15).

For Group 1, a torch flame was used to heat and eventually melt the alloy before it was forced into the mould. The gases used were a combination of natural gas and compressed air or natural air and oxygen/acetylene gas. The temperature range that is achieved from natural air and oxygen/acetylene gas provides a higher temperature range (1100°C-1300°C). Torch melting is commonly employed for melting alloys that have melting temperatures that are less than 1200°C [15].

The melting was carried out after the burn out stage, once the mould to be cast was placed and locked into position. Pellets of the desired alloy (five pellets from each brand) were placed into the crucible of the casting machine, and the torch was held over it until the alloy melted completely. The molten alloy was then forced into the mould either by centrifugal pressure [15-17]. This method is usually seen to be practiced in smaller dental laboratories.

Group 2: Ni-Cr alloy casted in Induction casting machine (n=15).

For Group 2, induction casting which is commonly employed in large laboratories for melting most dental alloys was used. This machine works on the principle of energy transfer that is used in transformers in which a coil carrying alternating electric current surrounds the container or chamber of metal. Circulation of Eddy currents in the metal produces extremely high temperatures which is used for melting the metals and making alloys of exact composition [15].

The induction heater comprises an electromagnet, through which high frequency alternating current is passed. The medium frequency generator (electromagnet) which is the heart of the machine is enclosed in sheet steel housing. A 110 kHz electromagnetic field is then produced which heats and mixes the molten metal to a homogeneous consistency [15].

To avoid overheating, the induction coils were water cooled. The crucible into which the alloy pellets are placed is held by the centrifugal arm in the casting chamber and the mould ring.

The heating element or the induction coil is usually located in the lower section of the chamber which rises and encircles the crucible when the program is initiated. Pellets of the desired alloy (5 pellets from each brand) were placed into the crucible of the casting machine. After the heating phase, the casting process was started. The melting of the alloy was observed through a protective glass integrated in the cover lid. Once the alloy reached casting temperature, it was forced into the crucible by centrifugal force [15-17].

The estimation of heavy metal concentrations from five samples of as-received pellets from each brand by using XRF was done as a standardising protocol. The concentration given by manufacturer for the brand I, II, and III, was noted and the mean values of the Ni, Cr, Co, and Mo concentration of as-received pellets from these brands were estimated by XRF.

The metal crowns were fabricated by using two different types of centrifugal casting machines i.e. acetylene-oxygen flame casting and induction casting machine. Elements present such as Ni, Cr, Co, and Mo in crowns fabricated from Ni-Cr alloys by flame gas torch centrifugal casting were measured by XRF machine. Percentage change of Ni, Cr, Co, and Mo from the crowns fabricated from different brands of Ni-Cr alloy by acetylene-oxygen flame and induction casting methods as compared to as received pellets was done. Percentage change equals the change in value divided by the absolute value of the original value, multiplied by 100 [18].

STATISTICAL ANALYSIS

Descriptive statistics was used such as mean, standard deviation and percentage and comparison between two methods were performed by using unpaired t-test. A p-value <0.5 was considered as significant. The test of significance used was t-test. Data analysis was performed by suing the statistical software Statistical Package for Social Sciences (SPSS) version 20.0.

RESULTS

The mean values of the nickel concentration of as-received pellets were 70.42%, 72.91%, and 66.07% for the brand I, II, and III, respectively and Ni concentrations given by manufacturer were 72.8%, 74.7%, and 65% of brands I, II, and III, respectively. These observations indicate, there was no difference between estimated elemental levels by XRF and composition given by the manufacturer [Table/Fig-6]. These results clearly show that the metal composition given by the manufacturer was nearly the same as estimated in this study from as received pellets by using XRF.

For acetylene-oxygen flame torch casting method, nickel levels were significantly decreased (-2.01% to -5.14%) from all three brands as compared to the elemental composition of the as-received pellets. Chromium concentration of brand I (-34.22%), brand II (-29.51%) and brand III (-7.35%) were significantly decreased. Molybdenum levels were significantly decreased (-19.32% to -96.33%), for all three brands as compared to the elemental composition of the as received pellets [Table/Fig-7,8].

Metals present in crowns fabricated from Ni-Cr alloys by induction casting method were measured by using an XRF machine. Nickel levels were significantly decreased (-3.39% to -4.22%) (-2.01% to -5.14%), from all three brands as compared to the elemental composition of the as-received pellets. Chromium concentrations were significantly decreased (-7.35% to -29.51%) from all three brands as compared to the elemental composition of the as-received pellets. Molybdenum levels were significantly decreased (-15.70% to -95.94%), from all three brands as compared to the elemental composition of the as-received pellets [Table/Fig-9,10].

Elemental composition present in crowns fabricated from Ni-Cr alloys by gas torch centrifugal casting method were measured by using an XRF machine and compared to induction casting method. All the constituent elements present were reduced but not significantly, except for nickel in brand III fabricated by induction casting method. The test of significance used was t-test [Table/Fig-11].

Cobalt level was not detected in all three brands of fabricated crowns by XRF by either of the casting methods. These observations indicate that the elemental composition of the fabricated crowns decreased as compared to that of as-received crowns, which could be due to the burnout of some amount of elements during casting.

DISCUSSION

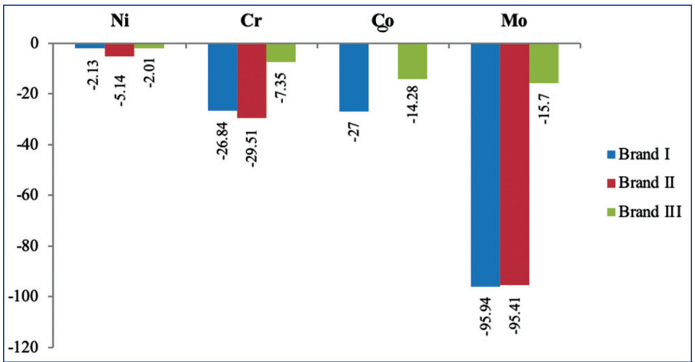
Commonly used casting methods are acetylene-oxygen flame casting and induction casting [15]. In the present study, the wax patterns were invested and cast by using acetylene-oxygen flame and induction casting techniques. The elemental compositions of the fabricated crowns of three different brands were compared to their respective as-received pellets.

Elements	Composition of Brand I alloy given by manufacturer	Composition of Brand I alloy recorded by XRF	Composition of Brand II alloy given by manufacturer	Composition of Brand II alloy recorded by XRF (Mean±SD)	Composition of Brand III alloy given by manufacturer	Composition of Brand III alloy recorded by XRF (Mean±SD)
Nickel	72.8%	70.42±0.58	74.7%	72.91±0.67	65%	66.07±1.07
		(69.5-71.1)		(72.12-73.79)		(64.45-67.20)
Chromium	4.9%	4.88±0.14	4.8%	4.71±0.39	22.5%	20.39±2.06
		(4.74-5.12)		(4.31-5.42)		(17.15-22.74)
Cobalt	-	0.86±0.31	-	0.80±0.43	-	0.07±0.03
		(0.3-1)		(0.3-1)		(0.04-0.14)
Molybdenum	-	1.48±0.04	-	1.09±0.08	9.5%	8.28±0.79
		(1.43-1.55)		(1.01-1.23)		(7.21-9.23)

[Table/Fig-6]: Estimation of metals present in as-received pellets of different dental casting alloy as compared with the compositions given by the manufacturer.
Figure indicate mean±SD values and range of values shown in Parentheses

Elements	Composition of Brand I pellet recorded by XRF	Composition of elements in fabricated crown from Brand I	Composition of Brand II pellet recorded by XRF	Composition of elements in fabricated crown from Brand II	Composition of Brand III pellet recorded by XRF	Composition of elements in fabricated crown from Brand III
	70.42±0.58	68.92±1.08***	72.91±0.67	69.16±2.00***	66.07±1.07	64.74±1.19**
Ni (%)	(69.5-71.1)	(67.04-70.34)	(72.12-73.79)	(65.39-71.81)	(64.45-67.20)	(63.12-66.79)
	p-value <0.0001		p-value <0.0001		p-value <0.0091	
	4.88±0.14	3.57±1.52**	4.71±0.39	3.32±1.34**	20.39±2.06	18.89±1.55*
Cr (%)	(4.74 – 5.12)	(1.33-4.90)	(4.31 – 5.42)	(1.33-4.38)	(17.15-22.74)	(17.08-20.74)
	p-value <0.0002		p-value <0.0008		p-value <0.0463	
Co (%)	0.86±0.31	BDL	0.80±0.43	BDL	0.07±0.03	BDL
	(0.3-1)		(0.3-1)		(0.04-0.14)	
	1.48±0.04	0.06±0.03***	1.09±0.08	0.05±0.02***	8.28±0.79	6.98±0.48**
Mo (%)	(1.43-1.55)	(0.04-0.13)	(1.01-1.23)	(0.03-0.13)	(7.21-9.23)	(6.23-7.87)
	p-value <0.0001		p-value <0.0001		p-value <0.0005	

[Table/Fig-7]: Estimation of metals from dental casting alloy after fabrication of crown by acetylene-oxygen flame torch casting as compared to the composition of the alloys in the As- received pellets recorded by XRF.
Figure indicate mean±SD values and range of values shown in Parentheses
Significance level as compared elemental composition of the respective alloy recorded ***p<0.0001,**p<0.001,*p<0,05,• not significant using unpaired t-test
BDL: Below detection limit was <01 µg



[Table/Fig-8]: Percentage change of nickel, chromium, cobalt and molybdenum from fabricated crowns of three brands of Ni-Cr alloys by gas flame torch castings as compared to elemental composition of as-received pallets.

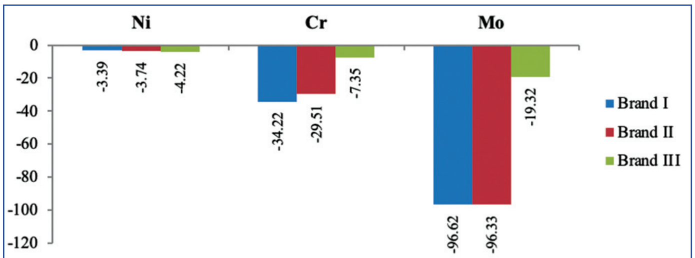
The composition of the as-received alloys are altered with the casting procedure is reported in the literature [19]. Also, other studies observed that the method of casting alters the elemental composition [19,20].

The XRF spectroscope is an analytical instrument used to quantify all metals composition from various materials. It is used to detect elemental composition in the paint industry, soil testing, steel industries, etc [14].

The scientist Cole introduced the acetylene-oxygen flame method and Taggart and Jameson introduced the induction casting method for casting metal crowns and both methods are regularly used in all dental laboratories [21]. The mechanical performance of base and noble metal casting alloys differ on which casting machine is used as reported in earlier studies [Table/Fig-12] [6,19,21-30]. The induction method for casting metal alloys is better than the acetylene-oxygen flame method since cooling is quicker due to more molten metal-

Elements	Composition of Brand I pellet recorded by XRF	Composition of elements in fabricated crown from Brand I	Composition of Brand II pellet recorded by XRF	Composition of elements in fabricated crown from Brand II	Composition of Brand III pellet recorded by XRF	Composition of elements in fabricated crown from Brand III
	70.42±0.58	68.03±1.43***	72.91±0.67	70.18±2.26***	66.07±1.07	63.28±1.19***
Ni (%)	(69.5-71.1)	(65.89-70.57)	(72.12-73.79)	(67.8-74.6)	(64.45-67.20)	(60.12-66.79)
	p-value <0.0001		p-value <0.0081		p-value <0.0001	
	4.88±0.14	3.21±1.62**	4.71±0.39	3.12±1.32**	20.39±2.06	18.73±1.47*
Cr (%)	(4.74 – 5.12)	(1.38-5.31)	(4.31 – 5.42)	(1.36-4.36)	(17.15-22.74)	(17.32-20.65)
	p-value <0.0005		p-value <0.0077		p-value <0.0427	
Co (%)	0.86±0.31	BDL	0.80±0.43	BDL	0.07±0.03	BDL
	(0.3-1)		(0.3-1)		(0.04-0.14)	
	1.48±0.04	0.05±0.03***	1.09±0.08	0.04±0.03***	8.28±0.79	6.68±0.54**
Mo (%)	(1.43-1.55)	(0.03-0.13)	(1.01-1.23)	(0.01-0.13)	(7.21-9.23)	(6.21-7.87)
	p-value <0.0001		p-value <0.0001		p-value <0.0001	

[Table/Fig-9]: Estimation of metals from dental casting alloy after fabrication of crown by induction casting as compared to the composition of the alloys in the as-received pellets recorded by XRF.
Figure indicate mean±SD values and range of values shown in Parentheses
Significance level as compared to elemental composition of the respective as-received pellet recorded ***p<0.0001,**p<0.001,*p<0,05,• not significant using unpaired t-test
BDL: Below detection limit was <1 µg



[Table/Fig-10]: Percentage change of nickel, chromium, cobalt and molybdenum from crowns fabricated from Brands of Ni-Cr alloys by induction castings as compared to the elemental composition of the as-received pellets.

investment contact in areas of high pressure [31] and these results shorten the solidification process and decrease grain size [32]. Overheating of the alloy may occur while using acetylene-oxygen flame casting. It may also result in increased surface roughness with the use of oxidising zone of the flame at lower temperatures and an environment rich in oxygen [33].

Similar results are reported in the literature by Thompson GA et al., they analysed 120 castability patterns by using centrifugal casting and inductively heated casting and evaluated specimen for casting completeness, porosity, chemical composition, Vickers microhardness, and grain analysis of microstructure and found the

Elements	Induction casting	Centrifugal casting	Mean difference	t-value	p-value
Comparison of Brand I DCA between induction casting and centrifugal casting methods					
Nickel	68.03±1.43	68.92±1.19	0.89	1.51	0.15
Chromium	3.21±1.63	3.57±1.22	0.36	0.57	0.58
Cobalt	BDL	BDL			
Molybdenum	0.06±0.04	0.07±0.03	0.012	0.76	0.45
Comparison of Brand II DCA between induction casting and centrifugal casting methods					
Nickel	70.18±2.26	69.17±1.84	1.02	1.10	0.28
Chromium	3.13±1.52	3.32±0.97	0.19	0.34	0.74
Cobalt	BDL	BLD			
Molybdenum	0.046±0.03	0.06±0.03	0.009	0.64	0.53
Comparison of Brand III DCA between induction casting and centrifugal casting methods					
Nickel	63.29±0.86	64.75±1.01	1.46	3.47	0.003
Chromium	18.74±1.42	18.89±1.07	0.16	0.28	0.78
Cobalt	BDL	BDL			
Molybdenum	6.69±0.55	6.98±0.63	0.29	1.11	0.28

[Table/Fig-11]: Estimation of metals from dental casting alloys after fabrication of crown by acetyelene-oxygen flame torch casting as compared to induction casting among three different brands.
Figure indicates mean±SD values. Significance level compared using unpaired t-test; BDL: Below detection limit was <01 µg

Author and year of publication	Place of study	Study hypothesis	Research finding
Shanley JJ et al., [21], (1981)	Bethesda Great Lakes III	To evaluate centrifugal casting and vacuum-pressure casting techniques for casting accuracy on removable partial denture frameworks.	With both casting methods, the differences between the casts and the castings were significant, but no significant differences were found between castings produced by the two techniques. Vertical measurements at three designated points also showed no significant differences between the castings.
Tajima K et al., [22], (1986)	Kitakyusku, Japan	The effect of the type of casting machine (centrifugal, vacuum-pressure, suction-pressure) on the tensile strength of nine commercial Ni-Cr alloys for crown and bridge and for ceramo-metal restoration, and of two precious alloys.	The tensile strength of both the study groups of Ni-Cr alloys were greatly influenced by the casting machine used, but did not that of the precious alloys group.
Wataha JC et al., [23], (1992)	Ann Arbor, Michigan	(1) Determine the in-vitro kinetic patterns of release of elements from several types of dental casting alloys which are used commercially, (2) determine the effects of an alloy-cleaning procedure on the release of elements, and (3) correlate the rate of release of elements with auger surface analyses of the alloys.	The present study demonstrated that the quantity of released elements were altered by the cleaning treatment and the percentages of the elements at the surfaces of several dental casting alloys, but did not change the kinetics of the release of the elements. The kinetic patterns of release for each element seemed to depend upon both the element and the alloy composition.
Wataha JC and Malcolm CT, [24], (1996)	Ann Arbor, Michigan	To relate the release of elements from alloys to their surface composition, and to determine the depth of the effect of the medium.	The surface concentration of noble elements is vital in preventing the release of non noble elements from these alloys, and the surface composition appeared to be only one or two atomic layers thick.
Hirata T et al., [25], (2001)	Osaka, Japan	The purpose of this investigation was, therefore, to examine the polishing behaviour of Ti and Ag±Pd±Cu± Au alloy with commercial dental abrasives driven by a speed-adjustable high torque micro motor engine.	Titanium was hard to polish, and probably requires special care (e.g. frequent exchange ofabrasives). Development of new abrasives for polishing titanium is needed.
Bezzon O et al., [6], (2004)	Brazil	The surface roughness of two base metal alloys, NiCr and CoCr, submitted to different casting techniques, and the influence on the loss of mass after polishing, as compared to commercially pure titanium castings.	The base metal alloys used under vacuum casting showed reduced surface roughness, similar to that of Ti, compared to base metal alloys submitted to acetylene oxygen flame casting.
Bauer JR et al., [26], (2006)	University of Sao Paulo	To evaluate the Vickers microhardness of three Ni-Cr alloys with different compositions under different casting conditions.	The microhardness of the alloys is dependent on the composition and method of casting. The hardness of the Ni-Cr alloys was higher when they were cast with the induction/air and flame/air torch methods.
Reddy SE et al., [27], (2007)	Dharwad, Karnataka, India	To evaluate the effect of finishing and polishing agents on surface roughness of cast commercially pure titanium using Scanning Electron Microscope (SEM) analysis.	Surface roughness of the cast CpTi specimens that were finished and polished for Ti was less.
Ayad MF, [19], (2008)	Tanta, Egypt	To characterise the elemental composition of an as-received and recast high noble alloy and to examine the in vitro corrosion behaviour in two media, using a potentiodynamic polarisation technique.	High noble alloy elements retained their passivity under electrochemical conditions that are similar to the oral environment in all casting protocols evaluated.
Reclaru L, et al., [28], (2012)	Switzerland	To evaluate their corrosion resistance (generalised, crevice and pitting corrosion) in artificial saliva and the quantities of cations released in particular Ni and Cr in relation with their microstructure.	No direct relationship was found between the in-vitro biological evaluation tests and the physicochemical characterisation of the studied alloys. Clinical and epidemiological studies are required to clarify these aspects.
Thompson GA et al., [29], (2013)	Milwaukee, West Indies	The castability of a dental alloy and the microhardness of a casting product are not affected by the choice of either alloy type or casting protocol.	There was no change in bulk composition of the casted alloy by two casting techniques, but rather a change in surface composition.
Elham A et al., [30], (2021)	Shiraz, Iran	To compare the castability of Ni-Cr, NPG and Co-Cr alloys, using torch/centrifugal casting machine and induction/vacuum-pressure casting machine.	The castability value of three different alloys tested in the study was not influenced by using torch/centrifugal or induction/vacuum-pressure casting machines.
Present study, 2022	Karad, Maharashtra India	To assess the composition of three base metal alloys, submitted to different casting techniques (acetylene flame gas torch and induction), to determine the influence of casting methods on composition after casting and compared to the as-received metal pellet.	The metal compositions were significantly reduced in fabricated crowns as compared to as-received pellets in all the three different brands. Both methods of casting altered the elemental composition of the alloy. The acetylene-oxygen flame gas torch casting caused more elemental reduction compared to induction casting method.

[Table/Fig-12]: List of previous literature related to different casting methods [6,19,21-30].

different surface composition of the same alloy cast by induction and centrifugal methods. This study clearly indicates that the metal composition of casting alloys and as-received pellet is different [29].

In this study we have measured heavy metal composition from fabricated crowns prepared by the two techniques such as centrifugal casting and inductively heated casting, however, in an earlier study done by Bezzon O et al., assessed the surface roughness of two different base metal alloys that were submitted to different casting techniques, and analysed the influence of surface roughness on the loss of mass after polishing and concluded that decreased surface roughness were observed in the base metal alloys fabricated from vacuum casting as compared to base metal alloys fabricated with acetylene-oxygen flame casting. There were no significant differences in loss of mass after polishing for all tested specimens [6].

From the previous reports and present results it can be speculated that the metal compositions are significantly reduced in fabricated crowns as compared to as-received pellets, maybe due to loss of some elements during fabrication process. Also, these results show the metal composition of the fabricated crown is different though not statistically significant in acetylene-oxygen flame and induction casting methods. The selection of dental casting alloy for clinical use should be based on the composition of the alloy as it is the deciding factor in the release of elements into the body fluids.

Limitation(s)

The limitation of the present study is that the repeatability of the data could not be investigated.

CONCLUSION(S)

On the basis of the findings and within the limitations of this in-vitro study, composition of three base metal alloys were assessed after submitting to different casting techniques and it may be concluded that a small amount of cobalt and molybdenum was detected in the as-received pellet though not mentioned by the manufacturer except for brand III alloys (Mo-1%). Also the metal compositions were significantly reduced in fabricated crowns as compared to as-received pellets in all the three different brands. Both methods of casting altered the elemental composition of the alloy. The acetylene-oxygen flame gas torch casting caused more elemental reduction compared to induction casting. Further studies are needed on the different methods of casting and milling.

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