The Effect of Bridge Orientation in Casting Machine on the Castability and Quality of Base Metal Castings

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Abstract

Introduction: The aim of this study was to evaluate the effect of bridge orientation in casting machine on castability and quality of base metal castings. **Methods:** Three groups of patterns with different direction and lengths in casting machine were casted and then studied qualitatively and quantitatively using mean and standard deviation in table of frequency. **Results:** Larger nodules and porosities were on the joints of sprue in horizontal specimens (P=0.01 and 0.048, respectively). There was no significant difference in castability between 3-, 5- and 6-unit bridges in relation to their direction in casting machine (P=0.5). An increase in bridge length led to more variation in length and width. The position of bridges also played an important role in the length variation in bridges. **Conclusion:** The direction of bridges had no effect on base metal castability but a vertical position resulted in a better casting quality and an increase in length of the bridges caused more defects in castings.

Key Words: Base metal, casting machine, dental casting technique.

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Introduction

Making a fixed partial denture (FPD) requires considerable clinical and laboratory skills and expertise. In order to construct porcelain fused to metal (PFM) restorations, the metal framework has to be formed first. Making an accurate metal frame work depends on many factors such as the type of the alloys, the design of the wax pattern, the sprueing technique, the type of the investment, the method of melting, and the casting technique (1-3).

To put it simply, the castability means the ability of the molten metal to completely occupy the mold created by the elimination of a wax pattern. Compensation for dimensional changes of the metal is a function of other materials involved in the process. If all factors involved in the process of casting are harmonious, the result will be the accurate fitting of the casting. Fitting is the ability of a casting to faithfully reproduce the pattern from which it was constructed (1,2).

When the wax pattern is completed and the sprueing is done, it will be placed in a cylinder with desired diameter; one important factor in casting is the direction of bridge in the casting machine (3).

Shillingburg et al. (3) reported that the orientation of invested fixed partial dentures in the casting machine can affect the flow of metal into the mold. The pattern is placed in a vertical position on the horizontal centrifugal casting machine to insure that all parts of the mold are filled simultaneously. To facilitate the proper orientation, a wax dot can be placed on the crucible former. This will leave a mark on the surface of the investment which can be seen when the ring is placed in the casting machine. As an alternative two opposite dots can be scribed on the ring. These dots should be aligned with the axis of the pattern before investing. After investing and burnout of the wax pattern, casting will be performed (3,4).

Dental alloys should have the capability of being casted in thin sections of desired length to obtain the best marginal fit. Due to the increased cost and demonstrated lack of stability of precious alloys for porcelain frameworks, the use of alterative alloys such as base metal alloys has been recommended (5).

In this study, the effect of bridge orientation on the castability and quality of base metal casting has been evaluated.

Materials and Methods

The objective of the test was to cast the pattern of plastic screen mesh containing diamond shaped spaces. Each filament of these diamond shaped spaces had 3mm length.

According to pilot study, 60 specimens in 3 groups were prepared:

Group A: 20 specimens with 30mm length similar to 3 unit bridges (10 diamond shaped spaces)

Group B: 20 specimens with 45mm length similar to 5 unit bridges (15 diamond shaped spaces)

Group C: 20 specimens with 60mm length similar to 6 unit bridges (20 diamond shaped spaces)

All three groups of bridges had 10mm width.

To facilitate the proper orientation, a wax dot was placed on the crucible former. This dot was aligned with the axis of the pattern before investing. This left a mark on the surface of the investment which could be seen when the ring was placed in the casting machine (Fig.1).

Deguvest investment (Dentsply, Germany) was used. All the investment was from the same batch. The liquid and powder were mixed under vacuum for 30seconds and vibrated in the same condition for 10 seconds.

The investment was allowed to set over night. A two-stage burn out procedure was used for all rings. Vera bond base metal alloy (Aalba Dent Inc. Cordia. CA, USA) was used to cast all the specimens. Manufacturer's instructions regarding the melting or casting temperatures and timing were followed.

Each group was divided into 2 subgroups of 10 specimens (A1, A2, B1, B2, C1, and C2). The specimens of the first and second subgroups were seated vertically and horizontally in the casting cradle, respectively. The casting were allowed to bench cool, divested manually and air-abraded with 50µm alumina oxide abrasive to remove residual investment and ultrasonically was cleaned in distilled water (Fig. 2). The sprue was sectioned 3mm away from the sprue-pattern junction.

The number of casted diamond shaped spaces was divided by the whole number of spaces and multiplied by 100 to determine the castability percentage for quantitative study of the castings. Large and small nodules and porosities in sprue joints of casting were also counted.

Results

Data was described by the mean, standard deviation and frequency tables. The Mann-Whitney, Wilcoxon and Fisher’s exact tests were used for data analysis ($\alpha=0.05$). Table 1 shows the qualitative and quantitative data of castings in vertical and horizontal positions.

Significantly more porosities and large nodules were present in horizontally positioned specimens. Qualitative variables improved in vertically positioned specimens.

The results of lengthening and widening of castings according to the position and number of units are shown in Tables 2 and 3. The differences were not statistically significant.

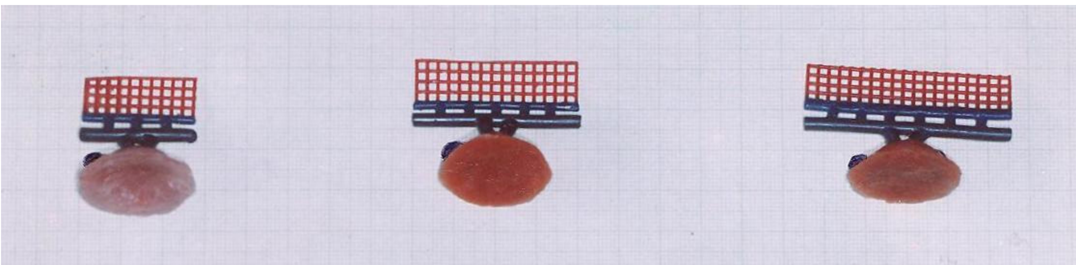

Figure 1. Three-, five-, and six-unit wax specimens with a dot on crucible former

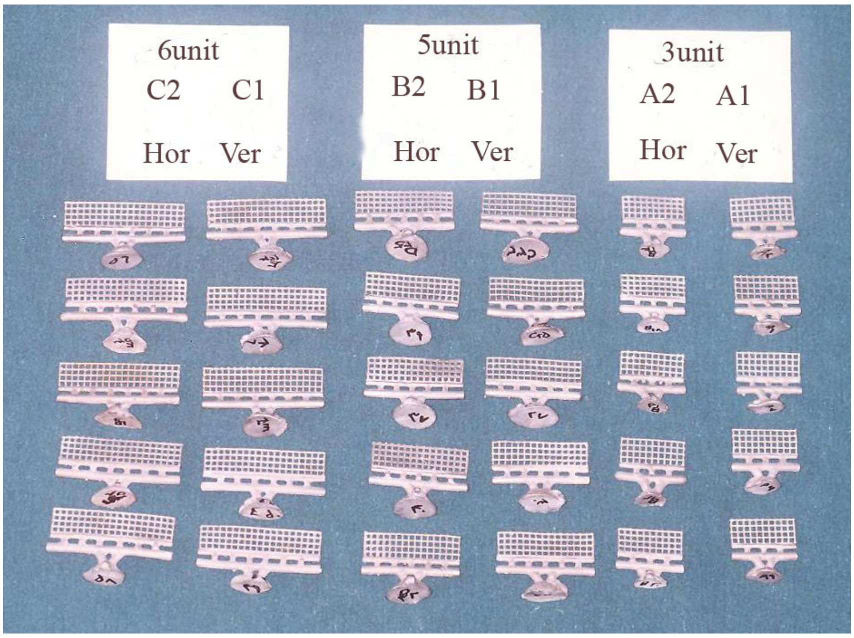

Figure 2. Casted bridge specimens in vertical and horizontal situation after sandblasting

Table 1. The qualitative and quantitative data of castings in vertical and horizontal positions

Test result	Position of casting				Variable
	Vertical		Horizontal		
	%	N	%	N	
$\chi2 = 5.4$ $P = 0.01$	70	21	93.3	28	Large nodules
$\chi2 = 1.1$ $P = 0.13$	80	24	90.0	27	Small nodules
$\chi2 = 2.7$ $P = 0.048$	10	3	26.7	8	Porosity
* P = 0.5	100	30	96.7	29	Complete casting

Table 2. Mean and standard deviation of lengthening variation of castings according to the position and number of units

The result of Mann-Whitney test	Vertical		Horizontal		Position of the units
	Median	Mean±SD	Median	Mean±SD	units
Z = 0.60 P = 0.54	-0.07	-0.16±0.22	-0.075	-0.1±-0.2	3
Z = 0.45 P = 0.64	-0.03	-0.02±0.07	-0.05	- 0.05±0.13	5
Z = 0.18 P = 0.85	-0.01	0.00±0.06	0.00	-0.00±0.22	6
Z = 0.78 P = 0.85	-0.05	0.06±0.015	0.06	0.05±0.88	

Table 3. Mean and SD of widening variation according to position and number of units in bridge

The result of Mann-Whitney test	Vertical		Horizontal		Position of bridges units
	Median	Mean±SD	Median	Mean±SD	
Z = 0.07 P = 0.93	0.00	0.04±0.144	0.02	0.01±0.05	3
Z = 0.19 P = 85	0.06	0.07±0.08	0.05	0.04±0.22	5
Z = 0.49 P = 0.62	0.03	0.02±0.06	0.04	0.04±0.11	6
Z=0.237 P = 0.81	0.03	0.01±0.10	0.02	0.00±0.14	

Discussion

Castability refers to the ability of a molten metal to completely occupy the mold created by the elimination of a pattern (5). The harmony among all elements in the process of casting results in an accurate fit of casting, which is the ability of a casting to faithfully reproduces the pattern from which it was constructed.

Various studies have been conducted on casting technique. Robert reported that the variation in length of casting depends on the type of investment, the expansion of investment, the type of wax pattern and the technique of sprueing (6). Presswood (1) examined the castability of alloys in small castings. The objective of this study was to cast the pattern of an extruded plastic screen mesh containing diamond shaped spaces. The diameter of the filament and the location of the pattern in the casting ring were explored to determine the castability of the pattern.

The number of spaces in the casting indicated the effectiveness of the metal to reproduce the pattern. In this study, the pattern invested vertically (1).

Dewald (7) reported that to minimize the possibility of incomplete casting due to improper pattern orientation relative to the sprue and the arm of the casting machine, mark the ring or sprue so that the invested pattern can be oriented properly in the casting machine arm. Wattanabe et al. (8) showed that the main factors that may give rise to problems in casting and internal porosities are the casting force exerted on the molten metal, the temperature of the melt and mold, the permeability of the investment and the spruing configuration.

Shillinburg et al. (3); however, emphasizes that the orientation of the invested fix partial denture in casting machine can affect the flow of metal into the mold. The pattern should be placed in a vertical position on the horizontal centrifugal casting machine to ensure that all parts of the mold are filled. Eissmann et al. (4) reported that when multiple sprue technique is used, the inlets should be aligned for the fastest and most uniform distribution of alloy within the mold. This means placing the inlets vertically in a horizontal casting machine.

In the current study, castings were made of base metal alloys. We give casting machine one or two extra winds in order to compensate lighter density of the base metal alloy. This may help the metal to flow in all parts of the mold simultaneously (3). We also tried to cast the pattern of plastic mesh which contains diamond shaped spaces, although this process is the most difficult technique.

All but one case was casted completely regardless of their position in the casting machine. This shows that the position of the bridge in casting machine had no effect on complete casting by Verabond (base metal) alloy.

Jarvis et al. (9) study showed that the increased amount of investment and number of wax diamond shaped spaces, vacco film sprinkling and increased investing time in longer bridges, affected the qualitative and quantitative properties of base metal castings. They also reported that the roughness of castings increased as burnout temperatures rose.

According to Table 1, the qualitative properties of castings improved in vertically positioned specimens. This is in accordance with Presswood (1) and Shillingburg et al. (3) studies. The gravity enables a better metal flow and also helps the melted metal to simultaneously occupy the mold.

Conclusion

1. The horizontal and vertical direction of bridges with different spans in casting machine had no effect on the castability of base metal alloys.
2. Vertical direction of bridges in casting machine improved the quality of castings.
3. Increasing in length of the bridges caused more defects in castings.

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