ORIGINAL RESEARCH

Comparison of Marginal Accuracy of Full Metal Crowns with Various Marginal Configurations and Casting Techniques- An Invitro Study

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ABSTRACT

Objective: Comparison of marginal accuracy of full metal crowns with various marginal configurations and casting techniques**. Materials And Method**: A dentoform molar was prepared with 3 different margin designs – Shoulder, Shoulder with a bevel and chamfer and 3 metal dies were casted. Each prepared group was divided into 2 groups (n=10) and casted with two different techniques – Group I: Ringless casting technique Group II: Metal ring casting technique. Crowns were seated under finger pressure, and the marginal discrepancy was measured under a stereomicroscope with 100X magnification.The collected data was analysed with ANOVA and Post hoc tukey test. **Results**: The marginal adaptation of crowns with a chamfer finish line was significantly better than crowns with a shoulder with bevel followed by shoulder finish line. Amongst the different casting techniques used ringless casting showed much less vertical discrepancy as compared to metal ring casting technique. **Conclusion**: The shoulder finish line specimens showed greater marginal gap than the chamfer finish line specimens. Accurate castings with better marginal fit can be produced by the ringless casting technique.

KEYWORDS: Casting techniques, Chamfer finish line, Marginal accuracy, Marginal configurations, Shoulder finish line

INTRODUCTION

All-metal full coverage crown is one of the most common and routinely fabricated restoration in fixed prosthodontics. Accuracy of the marginal fit, configuration, and location of finish line are important in the clinical acceptability of crowns to satisfy biological, physical, mechanical and cosmetic requirements.[1-3] The accuracy of fit of a cast restoration is essential for its longevity because of less plaque accumulation at the margins, thus providing better mechanical properties (retention, resistance), lesser cement space (fewer possibilities for leakage and recurrent caries) and improving the esthetic result.[2,3] Ni-Cr alloys have been promoted for castings in place of the gold alloys. A common problem encountered with the use of the base metal alloys is the casting shrinkage due to greater thermal contraction from higher solidification temperatures. It is essential to achieve compensation for the shrinkage of the solidifying alloy by investment expansion.[3,4] The use of the casting ring (conventional casting technique) was challenged with the introduction of a ringless technique. The high strength of the phosphate-bonded investment material makes it possible to cast without the ring. In literature, there are very few studies supporting the assumption that the ringless casting technique can produce accurate castings.[2]

MATERIALS AND METHODS

A dentoform molar was prepared using a round-ended tapered diamond secured on a resin block. A 0.6-mm chamfer was prepared, the taper of the axial walls was 5 degrees, and the preparation was 4 mm high. An acrylic resin pattern was fabricated from an additional silicone impression of the prepared tooth. A flat-ended tapered diamond was used to modify the chamfer margin into a shoulder configuration. A pattern was fabricated of the shoulder preparation in the same manner as for the chamfer preparation. A 0.5-mm-wide 45-degree bevel was added to the shoulder finish line, and then a pattern was made. The Duralay patterns with each of the three margin designs— chamfer, shoulder, and shoulder with bevel—were invested in Biosint Supra investment (Degussa). Three metal dies were cast out of a base-metal alloy (Biosil-F, Degussa) using a centrifugal casting machine. This metal die was used for the construction of 60 metal crowns using the Dentsply Vacu-press system.

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Margins were then sealed with conventional casting wax.

Specimens were divided into 2 groups (30 each) and casted with two different techniques –

- Group I: Ringless casting technique
- Group II: Metal ring casting technique

Each group was further subdivided into six (6) subgroups of ten (10) each (n=10).

Group I: Ringless Casting Technique

- Subgroup a): chamfer finish line (n=10)
- Subgroup b): shoulder finish line(n=10)
- Subgroup c): shoulder with bevel finish line (n=10)

Group II: Metal Ring Casting Technique

- Subgroup a): chamfer finish line (n=10)
- Subgroup b): shoulder finish line(n=10)
- Subgroup c): shoulder with bevel finish line (n=10)

The first group was invested with T phosphate-bonded investment (60 g/14 mL, with 70% liquid-to-water ratio, according to the manufacturer's recommendations, with a plastic ring of 3 cm. The second group was invested using T phosphate-bonded investment with a metal ring of 2.5 cm of diameter and a ceramic paper liner that was wetted for 1 minute according to the manufacture's recommendations. The water-to-liquid ratio used for each group was decided after some trial castings within the manufacturer recommendations so that the best clinically acceptable fit was achieved for each group. All investments used had the same lot number. Each coping was invested individually in 1 ring each, immediately after its fabrication. The investments were hand mixed for 15 to 20 seconds and then mechanically mixed for 30 seconds using the Degussa vacuum mixer. Each "ring" was left in a dry pressure pot for 5 minutes. After 10 minutes of initial setting, the molds of the ringless group were removed from the plastic rings. After 1 hour of air drying, they were all placed in the same oven (10°C/1 min soak temperature 260°C and final soak temperature 815°C) and cast with a high palladium metal-ceramic alloy (Argedent 52SF Argen Precious Metals Inc). Castings were divested with sandblasting with 50-µm glass beads and then steam cleaned. The castings were cut from their buttons and seated on the metal die using only finger pressure applied by the same "blind" operator. No adjustment of the internal surface of the castings was performed. Our goal in the design of this study was to eliminate all possible variables such as die spacer thickness, expansion of die stone, and polymerization shrinkage. For that reason, the metal die was used for waxing and measuring the seating accuracy. This introduces a limitation in terms of clinical interpretation. Crowns were seated on the metal die using finger pressure.

The margin discrepancy between the metal die and the castings was measured on stereomicroscope for the accuracy of measurements (2 µm, precision of measurements 0.5 µm) at a magnification of 100x.

Statistical analysis: The data was collected and statistically analysed with: 2 way- ANOVA and Post hoc tukey test.

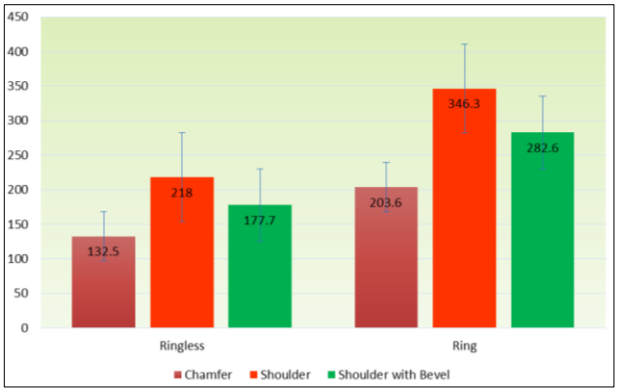
RESULTS

The mean vertical marginal discrepancy, standard deviation, and coefficient of variance for each group of castings are shown in Table 1.

Variable	Chamfer Mean± Sd	Shoulder Mean± Sd	Shoulder With Bevel Mean± Sd	f stats	p val#
Ringless Casting	132.5±20.69[a]	218±32.36[a,b]	117±21.89[a,b]	4.55	<0.0001
Ring Casting	203.6±37.70[c]	346.3±40.54[c,d]	282.6±28.38[c,d]		

Table 1: The mean vertical marginal discrepancy, standard deviation and coefficient of variance for each group
***In general highly significant difference was found between all the groups ($p < 0.001$),# using two way ANOVA. Using post hoc tukey test, [significant letters shows a statistical significant difference.

There was a highly significant difference among all the groups ($p<0.0001$). Castings produced with ringless investment produced lesser marginal discrepancies as compared to the castings produced with ringed method (Graph 1). Chamfer finish lines produced least marginal error followed by shoulder and shoulder with a bevel in each of the two groups.



Graph 1: 2 way Anova analysis of mean marginal accuracy in vertical discrepancy of ringless and ring castings with different marginal configurations.

DISCUSSION

Although the ringless casting technique is in use in fixed prosthodontics and implant prosthodontics, there are few investigations about the technique in the literature, and the accuracy of the castings depends on the skills of the technicians and is clinically determined by the dentists. Although the metal ring technique is clinically acceptable and allows for the fabrication of accurate casts, the metal ring does not allow the setting and thermal expansion of the investment[5-7] which is necessary to compensate for the shrinkage of the metal on solidification. To overcome this expansion restriction, a soft liner is used.[6,8] The ringless technique for investing and casting has been in use for many years for the fabrication of frameworks for removable partial dentures. It was introduced in fixed

prosthodontics technology.[9] With the use of a ringless technique, the restriction of thermal expansion that is associated with the presence of the metal ring is avoided. In this study, the margin discrepancy of castings produced with the ringless technique and the conventional technique using the metal ring were compared.

Some results showed that marginal seating is not influenced by either margin design or type of luting cement, while others reported that margin design significantly affects marginal seating.[10,11] Possible explanations for the conflicting results may be different testing methods and different materials used for die fabrication. Metal master dies, and crowns were used in this study to eliminate the damage to the die and crown surfaces and to standardize shape, size and surface roughness of the abutment and crown.

In a previous study, it was reported that both scanning electron microscope (SEM) imaging and light microscopy measurement techniques can be used to measure marginal discrepancies, since the accuracy of both the techniques was similar.[12] Thus the scanning electron microscope has been used in this study.

The measurements revealed that the chamber type of finish line design exhibited the least marginal discrepancy followed by the shoulder with the bevel and finally shoulder This can attributed to the fact that more the restoration margin ends with an acute angle, the shorter will be the distance between the restoration margin and the tooth, as had been described previously by Schillinburg, with the following formula: d= D sin m (d: marginal opening; D: the distance by which a crown fails to seat and m: the acute angle of the margin).[13]

All the castings with ringless technique produced least vertical marginal discrepancy because the complete expansion of the mould during setting of the investment occurred uniformly in all directions without any restriction. The marginal discrepancy was in clinically acceptable range.

The vertical marginal discrepancy of metal ring castings was more than ringless castings. This discrepancy can be attributed to the fact that although hygroscopic expansion also might have played some role and produces castings with a better fit, but the metal ring has a definite restrictive influence on the total expansion of the mould in this group. It is hypothesized that this expansion was uneven and it might have distorted the shape of the mould. The discrepancy was more than the clinically acceptable range. In the present study, the null hypothesis was that there will be no significant difference in the accuracy of fit of the castings produced by either technique. None of the castings in any group showed ideal marginal fit. The overall mean marginal discrepancy of restorations of all groups ranged from 95 µm to 136 µm. Though, this is not completely within clinically acceptable range (120µm), the reason for discrepancy can be explained on the following grounds; no adjustments were made on the internal surface of the castings; the spacer foil was reduced approximately 1.5-2.0 mm, and remargination was done with cervical wax. Because of this, castings might have bound more on the axial walls in this region, thus leading to a vertical marginal discrepancy. Because of the absence of the metal ring, none of the moulds of ringless technique cracked or fractured on their own during or after the casting. From the results and conditions of the study, a hypothesis can be made that the ringless technique allows free expansion of the investment and therefore produces castings that bind less on the die. It was also observed that there was least standard deviation in the castings of group A which means that this technique produced castings with more consistent results. Although the results of this study support the study by Lombardas et al[10] for the use of the ringless technique, the conventional metal ring investing technique is also well documented in literature, and is proven to produce acceptable castings. Further studies are needed to substantiate these results.

CONCLUSION

On the basis of the conditions of this in vitro study, it was concluded that the type of finish line employed, and casting technique has an influence on the marginal discrepancy and chamfer finish line with ringless technique produced castings with acceptable results.

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