Research Article

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A Comparative Evaluation of the Marginal Accuracy of Copings Fabricated, Single and Mutiple Per Ring, with Conventional Metal Ring Investing System and Ringless Investing System: An In Vitro Study

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ABSTRACT

Aim: This study compared the marginal accuracy of the copings fabricated, single and multiple per ring, with conventional metal ring investing system and ringless investing system.

Materials and method: The study consists of 40 samples (copings) which was mainly divided into two groups i.e. Group I- conventional metal ring investing system (20 copings) and Group II- ringless investing system (20 copings). Each group was further divided in two subgroups i.e. Group I-a, ten copings were fabricated using single wax pattern invested and cast individually with conventional metal ring investing system whereas Group I-b, ten copings were fabricated using ten wax patterns invested and cast together with conventional metal ring investing system. Group II-a, ten copings were fabricated using single wax pattern invested and cast individually with ringless investing system whereas Group II-b, ten copings were fabricated using ten wax patterns invested and cast together with ringless investing system. For measuring the marginal discrepancy, an optical microscope at a magnification of 100 x was used. Measurements were recorded on four surfaces of the die i.e. buccal, palatal, mesial and distal. The data was analysed with the T- test.

Results: The marginal discrepancy of the ringless group was significantly less than that of the conventional metal ring investing system ($P<0.00$). There was no statistical significant difference between the two subgroups that is single coping and ten copings fabricated per ring ($P > 0.05$).

Conclusion: The ringless technique may produce accurate castings for use in fixed prosthodontics, therefore further investigation is needed to develop a protocol for its use.

Keywords: Coping, marginal accuracy, investing, ringless, casting.

INTRODUCTION

Kasloff A[1] said, " To fulfil the requirements of an ideal restoration a casting must be made to fit the prepared tooth intimately." Success or failure of fixed restorations depends upon the number of factors; one of which is the marginal integrity.

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Marginal fit of the restoration helps in maintaining the harmonious relationship between the tooth, periodontium and restoration itself. Although the metal ring technique for investing is clinically acceptable and allows for fabrication of accurate castings, the metal ring to some extent restricts the setting and thermal expansion of the investment which affects the marginal fit of cast restorations.[2-6] The use of the casting ring was challenged with the introduction of a ringless technique as it overcomes the restriction of thermal expansion, which is associated with the presence of a metal ring.

The use of a metallic ring for investing wax pattern was first described by Taggart WH in 1907 (lost-wax technique).[2] Castings fabricated by his method were undersize and could not fit accurately due to restriction of thermal expansion of investment material. It was essential to achieve compensation for the shrinkage of the solidifying alloy by investment expansion. Weinstein & Coleman scientifically studied this method of compensation in the 1920's at the US National Bureaus of standard, which could help in obtaining marginal integrity of cast restorations. Today, the numerous methods for compensation of the alloy shrinkage on cooling are setting expansion,[7] thermal expansion,[8-11] and hygroscopic expansion of the investment.[6, 12-16]

Many studies show that the castings fabricated by the ringless technique fit better than conventional metal ring technique. The ringless techniques are also easier and less expensive. In the literature there are few studies comparing the two casting techniques for fixed restorations. This study was thus undertaken to evaluate and compare, under controlled laboratory conditions, the marginal accuracy of castings fabricated with ringless investing system and metal ring investment system, investing one pattern per ring and ten patterns per ring for both the groups. To all possible variances that resulted from the use of materials and techniques, such as gypsum, used for the production of gypsum dies, die spacer, and impression materials, a metal die was used on which all the wax patterns and measurements were made. The results of the study revealed that there was statistically significant difference between the two main groups i.e. metal ring and ringless investing system but it also shows that there was no significant difference between the two subgroups i.e. single pattern invested per ring and ten patterns invested per ring.

MATERIALS AND METHOD

This study was conducted at Government Dental College And Hospital, Mumbai in 2002.

Materials and ***armamentarium*** used for the study were as follows:

1. For fabrication of wax patterns- metal die which was custom made (maxillary premolar), die lubricant (True Release)-George Taub product Jersey City, electric wax bath and electrowaxer (Novo), PKTInstruments (Schuler Dental Ulm), inlay wax (Schuler Dental Ulm modelling wax blue-Germany), magnifying lens and wax calliper (Iwanson's gauge)

2. For spruing of wax patterns- 2.5 mm thick sprue wax (Schuler Dental Ulm wax), PKT Instruments (Schuler Dental Ulm), base with crucible former, True-blue (wax pattern cleanser and conditioner surfactant-Debubblizer, George Taub product, New York), casting rings which were metallic and plastic, 25 mm and 55 mm diameter each and ceramic casting ring liner (S.V. Denta Vlies asbestfrei, Schuler Dental Ulm)

3. For investing of wax patterns- weighing machine and vacuum mixer (Novo), distilled water, measuring cylinder, Begosol and Bellavest T (Bego Germany) and rubber bowl and straight spatula

4. For preheating and heating procedure- preheating furnace (Superfid Calde- Italy) and heating furnace (Aseg Galtoni-Italy)

5. For casting- induction casting machine (Aseg Gal toni-Italy), crucible (quartz containing) and casting alloy (Bellabond N. Bego- Germany)

6. For sandblasting- macro blaster air abrasive unit (USA)

7. For measurement of marginal accuracy- optical microscope (measuroscope)- Nikon 22 Japan

The ***method*** of study was divided into following phases: -

1. Preparation of a metal die

2. Fabrication of wax patterns
3. Spruing and investing of wax patterns
4. Preheating and heating procedure
5. Casting
6. Deinvesting
7. Measurement of marginal discrepancy

To standardize the study, 40 copings were directly fabricated on a metal die (maxillary premolar). Making of wax pattern, spruing, investing, casting, sandblasting and measurements were carried out by the same operator to minimise the operator's variability.

1. Preparation of a metal die (Fig. 1)-

A maxillary premolar ivorine tooth was prepared to receive a porcelain fused to metal restoration with 1.5 mm of shoulder margin facially and proximally and 1 mm deep chamfer margin lingually. The preparation was 7 mm in height with 4° angle convergence of axial wall. An impression of the ivorine[17] prepared tooth was made using custom tray with elastomeric material (Aquasil), which was later filled with pattern resin (GC Pattern) to get positive replica of prepared tooth. This pattern was invested with phosphate-bonded investment (Wirovest) and cast with cobalt chromium alloy (Wirobond). The casting was deinvested, sandblasted, finished and polished. This metal die was used for the construction of 40 copings. The markings were made on the metal die using fine carborandum disc on the buccal, mesial, palatal and distal surfaces of the die for measurement of marginal accuracy.[18]

Fig 1: Metal die (maxillary premolar)

2. Fabrication of wax patterns-

40 wax patterns were segregated into two main groups.

Group I: 20 wax patterns were invested and cast with conventional metal ring investing system which were further divided into two subgroups-

I-a) 10 wax patterns were invested and cast individually.

I-b) 10 wax patterns were invested and cast together.

Group II: 20 wax patterns were invested with plastic ring and cast with ringless system which were further divided into two subgroups-

II-a) 10 wax patterns were invested with plastic ring and cast indivually.

II-b) 10 wax patterns were invested with plastic ring and cast together.

3. Spruing and investing of wax patterns-

Spruing of wax patterns was carried out by direct method in which the sprue wax was directly attached with a flare to the wax pattern.[19] The base for the crucible former was prefabricated and made up of rubber with different indentations for various diameters of the rings. The crucible former was custom made with self cured clear acrylic resin (height-27 mm, diameter- 20 mm). The sprue former was prefabricated and made up of inlay wax (thickness-2.5 mm, length-20 mm). Spruing of the wax pattern was done by attaching the sprue former at 45° to the buccal cusp tip of the wax pattern. To avoid distortion of the wax pattern, the sprue former was attached to the pattern with the pattern on the master die. This was removed without distortion and attached to the crucible former in the centre of the ring so as to have uniform thickness of investment all around the pattern. The patterns were then treated by spraying debubblizer on them to reduce the surface tension and to ensure complete coverage of the intricate portion of the patterns by intimacy of investment material. The wax patterns were left to air dry. The investment used was phosphate bonded; carbon free material (Bellavest T, Bego). According to the groups the water powder ratio was calculated. The colloidal silica special liquid (Begosol, Bego) was measured with measuring cylinder and distilled water added to it. Then the measured powder was gradually added to the liquid in a clean rubber bowl. This mixture was hand spatulated for 30 seconds followed by vacuum mixing for 60 seconds. Mixed investment was poured in the ring with mild vibration. The invested wax patterns were allowed to bench set for 60 minutes as recommended by the manufacturer.

Spruing and investing for all the groups were same except that in group I-a, 25 mm diameter metal ring was used, water : powder ratio was 14 ml : 60 gms and liquid : water dilution was 70 ml : 30 ml according to the manufacturer's instructions.In group I-b, 55 mm diameter metal ring was used, water : powder ratio was 42 ml : 180 gms and liquid : water dilution was 70 ml : 30 ml according to the manufacturer's instructions. Patterns were stored in water at room temperature since in this group 10 patterns were invested together in one ring. Before spruing, wax patterns were subjected to remargination. During spruing care was taken to keep the same distance between 2 patterns i.e. approximately 4 mm which was measured with a compass. In both the subgroups I-a and b, casting ring liner (asbestfrei) was kept 3 mm short from the ends of the ring.

In group II-a, 25 mm diameter plastic ring was used, water : powder ratio was 14 ml : 60 gms and liquid : water dilution was 90 ml :10 ml according to the manufacturer's instructions. In group II-b, 55 mm diameter plastic ring was used, water : powder ratio was 14 ml : 60 gms and liquid : water dilution was 90 ml :10 ml according to the manufacturer's instructions. Patterns were stored in water at room temperature since in this group 10 patterns were invested together in one ring. Before spruing, wax patterns were subjected to remargination. During spruing care was taken to keep the same distance between 2 patterns i.e. approximately 4 mm which was measured with a compass. In both the subgroups II- a and b, plastic rings were detached from the mould after initial set of investment i.e. approximately 10 minutes to allow for unrestricted setting expansion of the investment.

4. Preheating and heating procedure-

The balancing of the invested rings was carried out in an induction casting machine (Aseg Galtoni) after one hour of bench setting.Then the invested molds were placed in preheating furnace (Superfid Calde) for wax burnout at room temperature (approximately 26° C). This temperature gradually increased to 250°C in 15-20 minutes. Then the molds were transferred to the main heating furnace which had the same temperature as that of the preheating furnace i.e. approximately 250°C. This temperature then gradually increased to 950°C.

5. Casting

The Ni-Cr alloy (Bellabond N), one pellet for group I-a and II-a whereas 4 pellets for group I-b and II-b were melted electrically in a ceramic containing quartz crucible and then cast into the mold centrifugally by motor action with induction casting machine. The casting temperature of the Ni-Cr alloy was 1350°C, which was kept constant for all the groups. The rings were then allowed to bench cool to room temperature (Fig. 2).

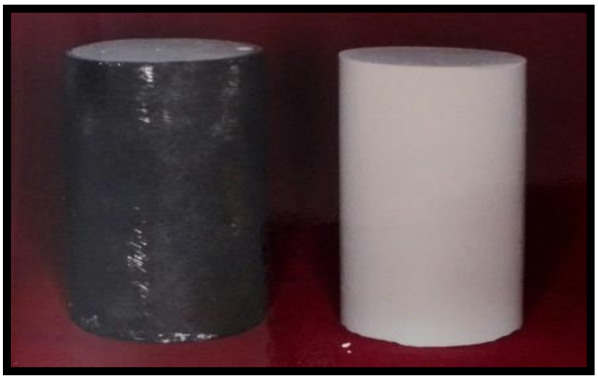


Fig 2: Invested molds for metal ring (Group I-a) & ringless (Group II-a) investing system

6. Deinvesting

The castings were deinvested by manually breaking away the investment material. Investment material that was difficult to remove between sprues and internal surface of copings was removed by sandblasting with 250 µ alumina particles. The copings were then cut from their buttons and seated on the metal die using only finger pressure applied by the same operator (Fig. 3). Internal surface of the copings was not touched or adjusted except for the nodules in 3-4 castings (Fig. 4).

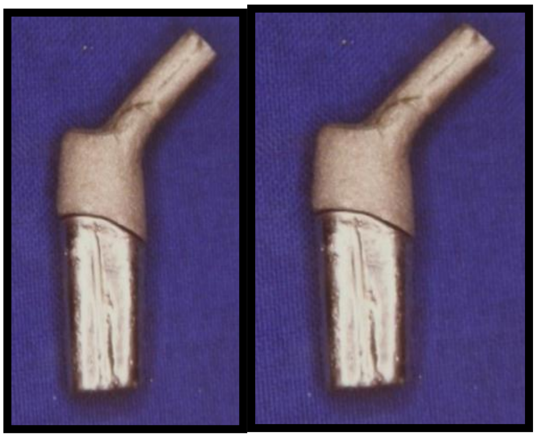


Fig 3: Casting on metal die for Group I-a & II-a

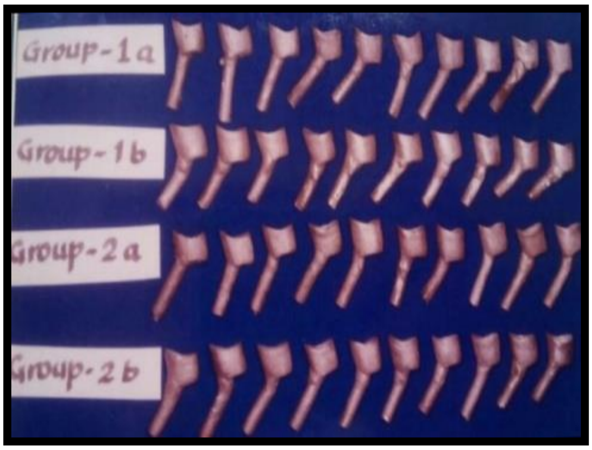


Fig 5: All specimens together (Group I-a, I-b, II-a, II-b)

Fig 4: Cast specimens of Group I-b & II-b

7. Measurement of marginal discrepancy-

The marginal discrepancy between the metal die and the copings was measured with an optical microscope (Nikon measuroscope model 22 Japan) at a magnification of 100 x. The measurements were made on predetermined areas that were marked on the metal dies on the buccal, palatal, mesial and distal surfaces. Each site was measured repeatedly by the same operator and the mean value of these measurements was used for statistical analysis.

RESULTS

Table 1: Mean marginal discrepancy in each site and group (Mean standard deviation)
[N=10 in each site & group]

Site→ Group↓	B	P	M	D
I (a) Single Casting/Ring	231.2±25.75 197 → 280 LR HR	225.5 ± 34.27 171 → 290	260.7 ± 34.79 216 → 316	293.2 ± 54.92 154 → 366
I (b) 10castings/Ring	248.9 ± 46.98 149 → 296	250.1 ± 43.07 205 → 336	250 ± 27.91 211 → 299	295.2 ± 45.07 255 → 367
II (a) Single Casting/Ring	149.3 ± 27.25 116 → 185	155.8 ± 24.76 108 → 185	155.4 ± 23.05 123 → 187	166.0 ± 24.54 129 → 197
II (b) 10castings/Ring	156.5 ± 25.37 121 → 199	166.9 ± 36.71 127 → 182	147.0 ± 34.0 101 → 219	176.0 ± 21.60 140 → 217

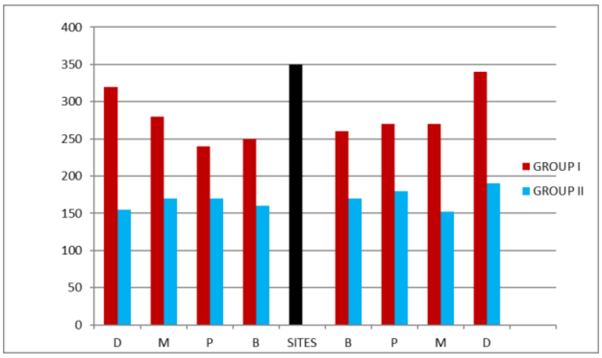
B- Buccal, P-Palatal, M-Mesial, D-Distal

Table 2: Groups compared for mean difference of marginal discrepancy

Site→ Group↓	B	P	M	D
I (a) Single Pattern vs I (b) Multiple Pattern	+ 17.7 (± 17.85) t : 0.99 Ns	+ 24.6 (± 18.35) t : 1.34 Ns	-10.3 (± 14.87) t : 0.69 Ns	+2.0 (± 23.68) t : 0.08 Ns
II (a)Single Pattern vs II (b) Multiple Pattern	+ 7.2 (± 12.41) t : o.58 Ns	+ 11.1 (± 14.76) t : 0.75 Ns	-8.4 (± 13.67) t : 0.61 Ns	+10.0 (± 10.89) t : 0.92 Ns
I (a) Single Pattern vs II (a) Single Pattern	-81.9 (± 12.49) t : 6.55 ***	-69.7 (± 17.09) t :4.94 ***	-105.3 (± 13.84) t :7.60 ***	+127.2 (± 20.05) t : 6.34 ***
I (b)Multiple Pattern vs II(b) Multiple Pattern	-92.4 (± 12.41) t : 7.44 ***	-83.2 (±14.76) t : 5.64 ***	-103.4 (± 13.67) t : 7.56 ***	-119.2 (± 10.90) t : 10.93 ***

(By T – test)
NS – Non-Significant P > 0.05,
*** - Highly Significant p < 0.00

Graph 1: Showing mean marginal discrepancy in microns (μ)



Single Coping Per Ring(a) Multiple Copings Per Ring (b)

Group I – Copings fabricated with metal ring investing system.
Group II – Copings fabricated with ringless investing system.
B - Buccal P – Palatal M – Mesial D -Distal

DISCUSSION

Many factors affect the overall acceptability of a cast restoration and many methods and techniques are used to improve it.[20] A cast restoration must seat precisely on the prepared tooth, exhibit a minimum cement margin not visible to the naked eye, be adequately retained and restore the function and esthetics. Marginal adaptation is a primary and significant factor in the prevention of secondary caries and is an important indicator of the overall acceptability of the cast restoration.[20] The ringless investing system was advocated to improve the marginal adaptation. Although the metal ring technique was clinically acceptable & allows for the fabrication of accurate castings, the metal ring restricts the setting & thermal expansion of the investment[2-6] which was necessary to compensate for the shrinkage of the metal on solidification. Finger W and Jorgensen KD[21] stated that the castings fabricated without a steel casting ring resulted in the accurate fit of the castings in the patient's mouth. The ringless technique for investing and casting has been in use for many years for the fabrication of frameworks for removable partial dentures but there was inadequate scientific data to support the use of this technique in fixed partial dentures.[18] With the use of the ringless investing technique, the restriction of thermal expansion, which was associated with the presence of a metal ring, is overcome.

In this study, the margin discrepancy of castings produced with the ringless technique and the conventional technique using the metal ring were compared. Throughout the study, the recommendations of the manufacturers were followed and the adjustment of the internal surfaces of the castings was not performed. Results of this study revealed that there was statistically significant difference between two main groups i.e. I & II but there was no statistical significant difference between two subgroups i.e. a. and b. Marginal discrepancy on the distal surface revealed more discrepancy which was attributed to the contour of the distal surface at CEJ. From the results & conditions of the study, a hypothesis can be made that the ringless technique allows for more expansion of the investment & therefore produces castings that fit snuggly on the die. However the conventional metal ring investing technique was well documented & proven to give acceptable castings and its use should not be abandoned. The study was carried out to verify & compare the ringless investing system that was proved to be also acceptable in teams of accuracy.

As this study shows that the fit of the copings was improved with ringless investing system & clinically seems to give passive fit, it may prove to be acceptable for implant supported restorations with alteration of liquid to water dilution during investing procedure.

CONCLUSIONS

Within the conditions of this study, the following conclusion were drawn-

1. The vertical marginal discrepancy of the ringless group for buccal, palatal, mesial and distal sites were significantly less than that of conventional metal ring investing system.

2. There was more marginal discrepancy on the distal surface of all the groups, which could be, attributed to the preparation design that is curvature of the proximal surface.

3. There was no statistical significant difference between two subgroups that is single coping fabricated per ring (Group-a) and 10 copings fabricated per ring (Group-b).

4. Many patterns can be invested and cast per ring, which gives clinically acceptable marginal accuracy of the copings.

5. The ringless investing system is clinically acceptable and can be used for the fabrication of fixed prosthesis.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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