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ORIGINAL ARTICLE

An *in vitro* Comparison of Marginal Accuracy in Temporary Crowns

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ABSTRACT

Purpose: To compare the marginal accuracy of temporary crowns *in vitro*, using two autopolymerizing temporary crown materials.

Materials and methods: Polyethyl methacrylate and bis-acryl composite were used to make 15 temporary crowns each, on an ivorine mandibular first molar, prepared as to receive a porcelain-fused-to-metal (PFM) crown. Matrices were made of polyvinyl siloxane impressions of a lower typodont arch. After crowns were fabricated, margins of the crowns were trimmed under magnification. Afterwards, margins of prepared tooth and crowns were marked. Each tooth-crown assembly was then observed under microscope (4×). With digital images of each surface, gap between margins of crown and preparation margin was measured in millimeters using computer software, after calibration. Two examiners made the measurements. Independent samples t-test and one-way ANOVA with Bonferroni post hoc analysis were applied to determine the mean marginal gap.

Results: Bis-acryl composite crowns exhibited 0.2 mm (SD ± 0.11) mean gap with greatest discrepancy at buccal margins. Mean gap with polyethyl methacrylate crowns was 0.3 mm (SD ± 0.17) with buccal and mesial margins exhibiting the greatest marginal discrepancy, at α <0.001.

Conclusion: Both materials did not exhibit ideal marginal accuracy, but temporary luting cement film thickness would compensate for the gap observed in the margins of bis-acryl composite crowns.

Keywords: Provisional restorations, Marginal gap, Self-polymerizing, Methacrylates, Polymerization shrinkage, Cement film thickness.

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INTRODUCTION

Prosthetic crowns are one of the most common dental therapies.[1] One third of dentate adults in the United Kingdom have at least one crowned tooth (34%) with 20% having one or two crowns and 5% at least six[2] while in the United States alone, it has been estimated that about 40 million crowns are placed in patients each year.[3]

Since, there is delay from the preparation of the tooth, until the time the definitive dental crown is fabricated in the laboratory and inserted into the mouth, provisional crowns are utilized in this interim period. The multiple important roles that a well-made temporary crown can fulfill should not be overlooked.[4] If vital teeth have been prepared, temporary crowns ensure patient comfort by preventing sensitivity. They provide occlusal and positional stability by maintaining intercuspal and proximal contacts, hence preventing untoward tooth movement. They also help to preserve the patient's masticatory activity and esthetics, especially in the case of anterior teeth.[5]

There are numerous properties looked for in an ideal temporary crown, but marginal accuracy is one of the most important feature of a properly fabricated provisional restoration.[6] A marginally accurate crown eliminates microleakage, thereby decreasing the chances of caries, pulpal inflammation or even pulpal degeneration, particularly in case of vital teeth.[7] Adequate marginal adaptation allows a cleansable contour against which the gingivae can heal, thus preventing gingival over-growth and subsequent difficulty in seating the final prosthesis. The margins of the prepared tooth are also protected from fracture if a marginally accurate temporary restoration is placed until the permanent crown is luted.[5]

Since, there are a wide variety of materials available to fabricate temporary crowns, it is difficult to choose one material that can efficiently fulfill the requirement of satisfactory marginal accuracy. Traditionally, methacrylate based provisional crown materials have been used to make interim restorations[8] but these exhibit polymerization shrinkage and an exothermic reaction on setting. Shrinkage may result in distortion that negatively affects the precise fit of temporary crowns.[9] Now bis-GMA composites, such as Integrity, are also available which are popular because of their ease of handling and shorter setting time.[10] Although manufacturers claim these materials have excellent marginal adaptability, conflicting results regarding their marginal accuracy have been obtained in studies comparing this property in various temporary crown materials.[11,12] Their drawback is that they are more expensive than methacrylate materials and tend to break when placed in areas of moderate stress.[7,8] Custom fabricated temporization can be achieved using direct, indirect or hybrid techniques, each with their own advantages and limitations.[13,14]

The objective of this study was to compare the marginal accuracy exhibited by provisional crowns immediately after fabrication, using two commonly employed autopolymerizing temporary crown materials. Since, the direct technique is commonly utilized in clinics for the fabrication of provisional crowns,[15] this method was adopted. The null hypothesis was that the marginal accuracy of a temporary crown is independent of the composition of the material used for fabrication.

MATERIALS AND METHODS

In this laboratory-based study, two autopolymerizing temporary crown materials were compared; (1) Integrity® (an autocure bis-GMA composite); and (2) Tempron® (a polyethyl methacrylate). The information of the materials tested, their composition, manufacturer and lot number are listed in Table 1. Ethical clearance had been acquired from the hospital's Ethical Review Committee before undertaking the study (ERC Exemption: 2019-OD-ERC-11).

Preparation of Test Specimen

Both materials were used to make 15 temporary crowns each. Two identical ivorine mandibular left first molars (Columbia Dentoform Corp, New York) were selected for the process of temporary crown fabrication. One of these teeth was kept intact, to be screwed in a mandibular typodont arch during the impression making. A sectional impression was made of the left mandibular quadrant with the unprepared tooth in place, using high viscosity polyvinyl siloxane (Aquasil Soft putty, Dentsply, Germany) in a rim-lock sectional tray. The unprepared tooth was then unscrewed and replaced with an identical left first molar, which had been prepared with diamond burs as to receive a porcelain fused to metal crown with a deep chamfer margin, 1 mm wide, and a taper of approximately 5°. Four reference marks were engraved at the midpoint of each surface of the prepared tooth, 1 mm below the preparation margin. These marks acted as references for subsequent measurements. The temporary crowns were made on this tooth.

Any provisional crown that exhibited internal or external voids, visible cracks or did not adapt to the prepared tooth along all four surfaces, was excluded from the final sample pool. The polyvinyl siloxane impression, made earlier, served as a matrix for temporary crown fabrication. The prepared tooth was screwed in the typodont arch in place of the unprepared tooth, and lubricated with a thin layer of petroleum jelly (Vaseline, Unilever PLC, London) to function as a separating medium. Integrity was injected into the matrix, using a dual-barreled syringe and the impression was placed onto the prepared tooth. The crown was fabricated according to manufacturers' instructions in terms of time taken for polymerization (3 minutes). After curing was complete, at least 30 minutes were allowed to elapse[16] before the margins of the crowns were refined using Soflex finishing disks (3M Dental Products, St. Paul, USA) under magnification of loupes (3.5×) until they were deemed smooth. Loupes were used to prevent the inadvertent excessive trimming of the crown margins. In a similar manner, 14 more temporary crowns were fabricated and their margins trimmed. A new polyvinyl siloxane impression was made for fabrication of each crown.

After crowns had been made with Integrity, Tempron was also used to fabricate temporary crowns. When the polyvinyl siloxane impression had been made, the PEMA powder and liquid was hand-mixed in a ratio of 1:1 according to manufacturer's instructions. The material was poured into the impression matrix and when it exhibited matte finish, was placed on the prepared tooth and allowed to set. Crowns made using this material were repeatedly removed and reseated during polymerization, as described by Moulding et al.[17] This was in accordance with the direct technique mimicked in clinics when using PEMA-based materials, in order to protect the tooth from the elevated temperature during final polymerization and to prevent the locking of crown onto the tooth.[18] The margins of these crowns were also finished in a manner mentioned earlier. The separate groups of crowns were numbered from 1 till 15 and their margins were marked using blue ink (Fig. 1A). The preparation margin on the ivorine tooth was marked with red ink (Fig. 1B). All these procedures were undertaken be a single operator.

Measurement of Marginal Discrepancy

Four wax molds were made in order to act as standardized holders and help replicate the position in which each crown-tooth assembly would be placed under the microscope, along their buccal, lingual, mesial and distal surfaces (Fig. 2). The prepared typodont tooth was unscrewed from the arch. Each crown was seated on the prepared tooth, one by one, with digital pressure. After placing this tooth-crown assembly in each of the wax molds, all four surfaces of the crown were observed under the microscope (Olympus Microscope BX41, Olympus America, Melville, NY) equipped with DP70 Digital System, at 4× magnification. The field of view was kept as to observe the gap between the margins of the temporary crown and that of the prepared tooth in line with the reference mark. Once focused, the image of each surface was digitally captured. The first digital photograph had a micrometer scale added to it, in order to calibrate the

Table 1: Materials tested in the study

Brand name	*Manufacturer*	*Composition*	*Lot number*
Integrity®	Dentsply Caulk, Milford, DE, USA	Microfilled bisphenol A-glycidyl dimethacrylate (bis-GMA) composite resin	655190
Tempron®	GC Corporation, Tokyo, Japan	Polyethyl methacrylate (PEMA)	0612051

software program to measure the distance between the two margins in millimeters.

Image Analysis

After images from all the surfaces of each temporary crown were saved, computer software (Image Tool Software Version 3) was calibrated and the distance between the crown margins and the margin of the prepared tooth was measured. Measurements were made by two examiners, along a straight line running from the reference point, bisecting both margins at 90° (Fig. 3). One was the primary investigator, and the other examiner was blinded as to which image belonged to which of the two groups. Measurements along all four surfaces for each crown were recorded. The marginal discrepancy was calculated as the arithmetic mean of the four measurements.

Agreement between Assessors

Pearson's correlation coefficient was used to calculate the interexaminer reliability. The assessment was made on 32 readings out of 120 (26.6%). It was found that there was 0.982 agreement between the two examiners for the measurements made in the bis-GMA composite group and 0.946 interexaminer agreement for the observations made in polyethyl methacrylate group.

DATA ANALYSIS

SPSS 19.0 for windows was used for statistical analysis. Independent samples t-test was applied in order to compare the mean marginal discrepancy in the two groups. The margins exhibiting the most gaps were determined by using one-way analysis of variance (ANOVA) with Bonferroni post-hoc analysis. Level of significance was kept at 0.05.

RESULTS

Table 2 shows the mean and standard deviation of the marginal discrepancy exhibited by each group. The independent samples t-test demonstrated both groups exhibited statistically significant marginal discrepancy ($p < 0.001$). Table 3 shows the surface specific marginal discrepancy,

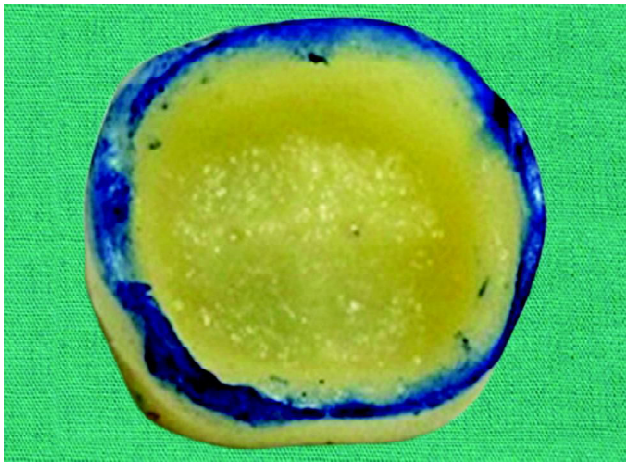

Fig. 1A: After trimming, margins of the crowns were marked with blue ink

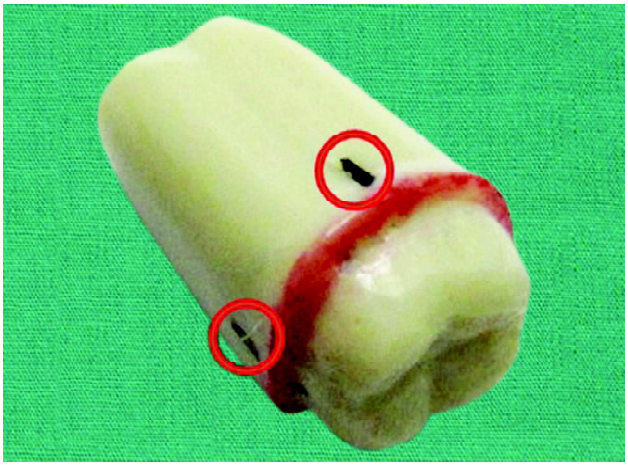

Fig. 1B: Margins of the prepared tooth marked with red ink. The reference marks are also visible

Fig. 2: The crown-tooth assembly on a wax mold, to be visualized under the microscope

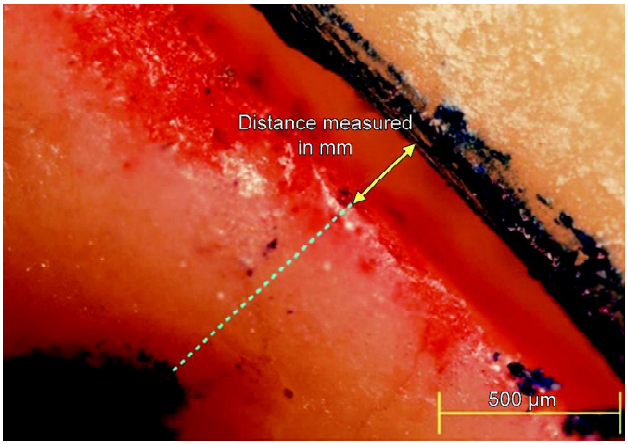

Fig. 3: The digital image used to measure the marginal gap. Note the micrometer scale incorporated in the image

demonstrating that the buccal and mesial surfaces of the polyethyl methacrylate group were responsible for the greatest marginal gap overall. In the bis-GMA composite group, the highest value of marginal discrepancy was seen on the buccal margin. One-way analysis of variance (ANOVA) with Bonferroni post hoc analysis (Table 4) showed that statistically significant differences exist between the four surfaces. Highest marginal discrepancy was observed when the buccal margins were compared with the lingual margins as well as when the lingual margins were compared with the mesial margins.

DISCUSSION

Marginal adaptation is a measure of the polymerization shrinkage, stress release and plasticization of a material when a crown is cemented on the tooth for a period of time.[6] This study aimed to determine the primary marginal fit of provisional crowns, which is the marginal fit directly after fabrication without any significant trimming or relining, and prior to cementation.[16]

The proposed null hypothesis was rejected, as there was a statistically significant difference between the marginal accuracy of both materials used. In this study, the provisional crowns were fabricated using a direct technique, commonly employed in clinical practice. All provisional crowns made using any one material were fabricated, and their marginal gap recorded, within 24 hours of fabrication in order to minimize the effects of polymerization shrinkage over time and standardize the conditions of the experiment. Each temporary crown was fabricated on the same prepared

Table 2: Comparison of marginal discrepancy of the two temporary crown materials

	Marginal discrepancy observed at 4× magnification			
Materials	*Number of surfaces observed*	*Mean (mm)*	*SD (mm)*	*p-value*
Integrity®	60	0.20	0.11	<0.001
Tempron®	60	0.30	0.17	

Independent samples t-test was applied at 0.05 level of significance

Table 3: Marginal discrepancy according to material and surface

Surface of temporary crown	*n*	*Mean gap (mm)*	*SD (mm)*
Buccal of Integrity	15	0.29	0.11
Lingual of Integrity	15	0.16	0.09
Mesial of Integrity	15	0.19	0.11
Distal of Integrity	15	0.18	0.11
Buccal of Tempron	15	0.37	0.11
Lingual of Tempron	15	0.18	0.17
Mesial of Tempron	15	0.37	0.18
Distal of Tempron	15	0.29	0.15

Table 4: Comparison of mean marginal discrepancy of crown surfaces (n = 120)

Source	*Sum of squares*	*df*	*Mean square*	*F*	*p-value*
Between groups	0.428	3	0.143	6.557	<0.001
Within groups	2.522	116	0.022	—	—
Total	2.950	119			

Surfaces		*Mean difference (mm)*	*Standard error*	*p-value*
Buccal	Lingual	0.16	0.03	0.00
	Mesial	0.04	0.03	1.00
	Distal	0.09	0.03	0.09
Lingual	Buccal	0.16	0.03	0.00
	Mesial	0.11	0.03	0.02
	Distal	0.06	0.03	0.45
Mesial	Buccal	0.04	0.03	1.00
	Lingual	0.11	0.03	0.02
	Distal	0.04	0.03	1.00
Distal	Buccal	0.09	0.03	0.09
	Lingual	0.06	0.03	0.45
	Mesial	0.04	0.03	1.00

One-way ANOVA was applied with Bonferroni post-hoc analysis at 0.05 level of significance

ivorine tooth to miminize the chances of error during making of duplicate dies. The margins of the crowns were trimmed under magnification of loupes instead of a microscope, to mimic the procedure done at the chairside. Also, a standardized position for each crown-tooth assembly was assured along all surfaces by placement in specific wax molds during observation. The ivorine teeth, on which impressions and temporary crowns were made, had been screwed in a typodont arch with adjacent teeth present. This was done in order to replicate the common intraoral condition where a tooth requiring a crown has sound adjacent teeth mesially and distally. Hence, the effect of the presence of adjacent teeth on the accuracy of impression and fabrication of the temporary crown was taken into account. The software used to measure the marginal gap was calibrated before measurements were made and two examiners measured the gap observed using the digital images. This helped to decrease bias as one of the examiners was blinded. These factors make our study unique when compared to similar studies done in the past.

Various studies have been conducted describing the marginal accuracy of different temporary crown materials.[6,11,12,18] With smaller sample sizes, the results and statistical inferences may be debatable. According to Groten et al,[19] 50 measurements per crown are required to obtain clinically relevant information about gap size, regardless of whether the measurement sites were selected in a systematic or random manner. The smaller number of measurements must be compensated for by increasing the number of surface evaluations, as has been done in our study. Four measurements per specimen have been made in previous studies (labial, mesial, distal and lingual). However, the individual margin responsible for the greatest marginal discrepancy has not been identified. In this study, with 60 observations in each group (a total of 120 observations), it was demonstrated that the buccal and mesial margins of the crowns made using Polyethyl methacrylate demonstrated the greatest marginal gap. In the bis-GMA composite group, the buccal margin alone was mainly responsible for the marginal discrepancy. Although, polymerization shrinkage has been deemed responsible for the lack of marginal adaptation in provisional crowns,[6,11,12,16,18] it can also result from distortion of the margins when the crown is removed and reseated during the final stages of polymerization.[5] The common finding of deficient buccal margins in both groups could be attributed to the lifting of crowns from the buccal aspect during removal, but the cause of this finding needs to be further investigated. Regarding marginal design of the preparation, according to Keyf,[20] no significant difference existed in the fit of provisional crowns when either shoulder or chamfer margins were prepared.

Variation exists regarding what constitutes a clinically acceptable margin.[21] For optimum health of periodontal tissues, the marginal adaptability of a temporary crown should be as accurate as that of the final prosthesis.[22] In some articles,[23,24] marginal gaps and cement thicknesses of less than 120 μm have been described for the success of a restoration. According to McLean,[25] a marginal opening of 100 μm (0.1 mm) is at the borderline of acceptability in permanent crowns, which should also be applicable in case of temporary crowns. A convenient range for film thickness of luting cements have been described between 50 and 100 μm[26] but current ISO standards (ISO 3107: 2004) require a film thickness at the time of seating of no greater than 0.25 mm for water-based luting cements (including temporary cements used for luting provisional restorations). Revised ANSI/ADA Specification No. 30 also recommends film thickness of zinc oxide eugenol or zinc oxide noneugneol temporary luting cements (type I) to be a maximum of 25 μm. In light of this recommendation, it can be assumed that the mean marginal gap observed in polyethyl methacrylate group (0.3 mm) would not be compensated for by the thickness of the temporary luting cement. The marginal gap recorded for the bis-GMA composite group (mean marginal gap of 0.2 mm) would be filled by the thickness of the temporary luting cement and hence, crowns made using this material have a decreased chance of microleakage as a result of inadequate marginal adaptation. As bis-GMA composite also demonstrated significant marginal gap, it can be assumed that distortion as a result of polymerization of methacrylate is not the only factor responsible for the marginal inaccuracy.

Some limitations of this study were that oral conditions, in terms of occlusal loading and thermocycling, were not replicated. Also, finger pressure was used to seat the provisional crowns on the prepared ivorine tooth, which is not a standardized methodology, although this is the technique by which crowns are seated in the mouth clinically. Marginal gap should be observed after cementation of provisional crowns, in order to evaluate the degree to which the marginal discrepancy is compensated for by the luting cement. The gap should also be assessed overtime, to determine the changes in marginal adaptation. Investigations regarding methods that could be adapted to decrease the effects of polymerization shrinkage should be undertaken. Temporary crowns made using similar materials in an indirect technique should also be evaluated for the degree of marginal discrepancy.

CONCLUSION

Within the limitations of this study, it can be inferred that although both materials do not fulfill the ideal requirements

of marginal adaptability, crowns made using bis-GMA composite exhibited a marginal gap which could be filled by the film thickness of temporary luting cements. For long term use, provisional crowns made using indirect technique may be more suited, as those fabricating materials would be processed with heat and pressure, improving their density and decreasing the degree of polymerization shrinkage.[27]

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