

Comparison of marginal accuracy in two different materials used in provisional crown and bridge – an in vitro experimental study

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Abstract

Objective: To determine the difference in the marginal accuracy at buccal, lingual, mesial and distal margins of temporary crowns fabricated with bisacryl-based temporary crown material.

Method: The in-vitro, experimental, laboratory-based study was conducted at the Aga Khan University, Karachi, from September to December 2019, and comprised two bisacryl-based temporary crown material, Integrity and Protemp 4, which were used to fabricate a sample of 24 temporary crowns. A pre-operative polyvinyl siloxane impression served as a template for temporary crown fabrication. A right mandibular molar tooth on a typodont was prepared to receive a crown. The provisional crown material was syringed onto the template and was allowed to cure. All four surfaces of the crown were observed under a stereomicroscope equipped with digital single-lens reflex camera at 25.6x magnification. An image of each surface was captured and a photographic record was maintained. An image processing software was used for the measurement of marginal discrepancy. Marginal accuracy among the four surfaces was assessed. Data was analysed using SPSS 23.

Results: Mean marginal discrepancy for provisional crowns fabricated with Protemp 4 and Integrity was $410 \pm 222 \mu\text{m}$ and $319 \pm 176 \mu\text{m}$, respectively. The marginal discrepancy between the two groups was statistically significant ($p=0.027$), with buccal margin exhibiting the most discrepancy ($p<0.01$).

Conclusions: Integrity showed less microleakage than Protemp 4. Among all the walls, the buccal wall showed the most microleakage. Marginal accuracy was found to be dependent upon the type of provisional crown material and the side of the prepared axial wall.

Key Words: Crowns, Dental marginal adaptation, Tooth preparation, Dental materials.

(JPMA 73: 567; 2023) DOI: 10.47391/JPMA.5008

Submission completion date: 03-12-2021 — Acceptance date: 29-09-2022

Introduction

Provisional restorations represent an important interim management step in a number of dental procedures.¹ They serve as intermediate restoration before the delivery of the final indirect prosthesis. Their role in the oral cavity from the time of tooth preparation to the time of insertion of indirect prosthesis cannot be overlooked. The purpose of temporisation is multifold: it can be used to prevent pulpal sensitivity when the teeth prepared have a vital pulp; it maintains aesthetics when placed in the anterior zone; the masticatory activity is preserved; and it prevents untoward movement by maintaining stable occlusal and interproximal contacts.^{2,3}

Temporary restorations essentially have the same requirements as those for a permanent restoration, except their longevity. However, the most important requirement for success is marginal accuracy of these temporary crowns.⁴ A properly fabricated provisional

crown eliminates microleakage, thereby decreasing the odds of secondary decay.⁵ A temporary crown with a good marginal adaptation will maintain the health of the periodontal tissues and allow for proper gingival contours, thereby facilitating impression and cementation procedures. This will prevent gingival overgrowth which can result in difficulty in seating the final indirect restoration.⁶

Currently, there are various materials that can be used to fabricate temporary crowns, which makes it a challenge to find the right material that can effectively form an accurate marginal seal. Conventionally, methacrylate materials had been used to make temporary restorations.⁷ However, these materials showed low mechanical properties, lack of marginal integrity and poor colour stability.⁸ In recent years improved interim restorative materials with better aesthetics and longevity have been introduced. These newer materials are bis-glycidyl methacrylate and bisacryl-based.⁸

As there is a wide variety of temporary crown and bridge materials to choose from, it becomes difficult to select one material that exhibits the best mechanical properties

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out of them all. The current generation bisacryl material demonstrates ease of handling and a convenient setting time. Integrity is one such popular bisacryl-based temporary material that has shown a good track record. This material can be polished to a natural lustre for enhanced aesthetic results. Its consistency allows for easy manipulation of material and results in faster cleanup. Due to their decreased polymerisation shrinkage, these materials require minimal adjustments. The introduction of better bisacryl-based products led to their increased demand in the industry. The initial data of the fourth iteration of Protomp line of temporary crown and bridge material, the Protomp 4, showed good results following performance evaluation for fracture toughness, flexural and compressive strength. However, no claims regarding marginal accuracy were made in the technical datasheet.⁹ Marginal adaptation is an integral property that needs to be taken into consideration before deciding upon a provisional material.

In a study,³ the mean marginal discrepancy of Integrity temporary crowns was $200 \pm 110 \mu\text{m}$ which was similar to that found in another study which reported the marginal discrepancy to be $218 \pm 65 \mu\text{m}$ ¹⁰. Protomp 4 showed mean marginal discrepancy of $63.44 \mu\text{m}$ and $71.59 \mu\text{m}$, respectively^{11,12}. Despite having similar study design, the differences in methodology may have contributed to the final outcome. The studies differed with respect to preparation of the abutment tooth, use of separating media, magnification and finishing protocols. The current study was planned to evaluate the two materials using a standard methodology to determine the difference in marginal accuracy at buccal, lingual, mesial and distal margins of temporary crowns. The null hypothesis was that there would be no difference in marginal accuracy between the two materials.

Materials and Methods

The in-vitro, experimental, laboratory-based study was conducted at the dental department of the Aga Khan University, Karachi, from September to December 2019. After approval from the institutional ethics review board, the sample size was calculated using Open Epi software¹³. In the light of literature^{3,11}, the mean difference between Integrity and Protomp 4 groups was $106.12 \mu\text{m}$, and the value was used with 95% confidence interval (CI) and 90% power. Since there were two groups, 24 temporary crowns were needed to test the null hypothesis.

Integrity (Dentsply Caulk, Milford, DE, United States) and Protomp 4 (3M ESPE, St. Paul, MN,

United States) were used to fabricate 12 temporary crowns each. An ivorine mandibular right first molar was selected for the process of temporary crown fabrication. A pre-operative sectional impression of the quadrant was taken using Aquasil (Dentsply, Konstanz, Germany), a high-viscosity polyvinyl siloxane, in perforated stainless-steel stock trays. The impression served as a template for temporary crown fabrication for both groups. An additional polyvinyl siloxane impression was obtained to serve as an index for tooth preparation. The tooth was then prepared with diamond burs to receive a crown. The tooth reduction resulted in a circumferential shoulder marginal configuration. Four reference points were marked at the midpoint of each surface, starting from the edge of the preparation margin. These points were used subsequently to assess marginal accuracy. A thin layer of petroleum jelly (Vaseline, Unilever PLC, London, United Kingdom) was applied to serve as a separating medium. Following the manufacturer's instructions, the temporary material was injected from the double-barrelled syringe into the polyvinyl siloxane impression, which was then seated onto the prepared tooth and allowed to set for 3min. The crowns were moved slightly in an up-and-down motion from the abutment during polymerisation to simulate the direct technique. If the temporary crown remained seated on the prepared tooth after the removal of the impression, it was teased off with a gauze using along the path of insertion using finger pressure. The temporary crown was allowed to rest for 30min before refining the margins using coarse grit Sof-Lex finishing discs (3M ESPE, St. Paul, MN, US). The discs were used at 10000rpm until the crown margins were deemed smooth. Each crown was numbered and stored until further intervention. To facilitate demarcation of the tooth and crown margins for software analysis, the former was marked with red ink, whereas blue ink was used to mark the latter (Figure 1). Temporary crowns that exhibited adaptation to the abutment on direct visual assessment

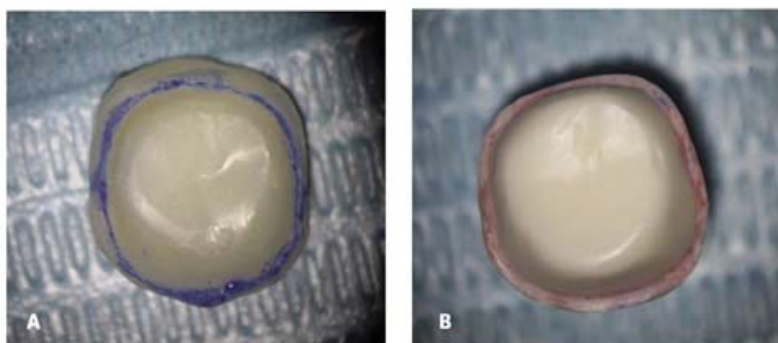


Figure-1: Temporary crown margins marked with blue ink (Left). Prepared tooth margins marked with red ink (Right).

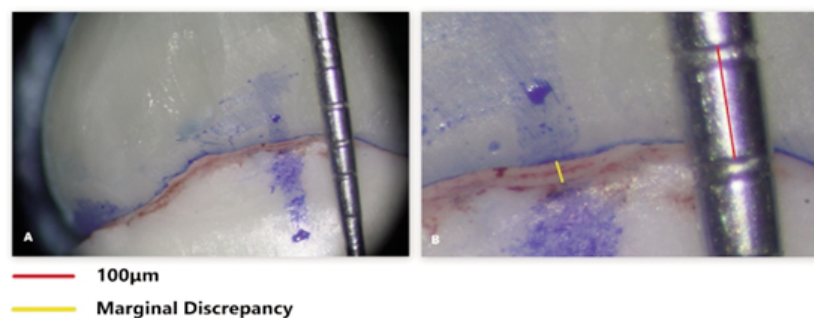


Figure-2: (A) Crown and tooth assembly ready for image analysis. (B) A straight line (red) drawn from one graduation to the next to calibrate the software. Another straight line (yellow) was drawn from the prepared margin to the crown boundary at the point of reference.

were included in the study. All temporary crowns exhibiting voids or cracks were excluded.

The prepared tooth was unscrewed from the typodont model for the assessment of marginal accuracy. The temporary crowns were seated on the prepared tooth, one by one, with digital pressure. All four surfaces of the crown were observed under a stereomicroscope (AM-4000, ALLTION, Guangxi, China) equipped with digital single-lens reflex (SLR) camera (Canon EOS 70D) at 10.4x magnification. Once focussed, the image of each surface was captured and a photographic record was maintained. At the time of capturing the photograph, a graduated probe with millimetre markings was kept adjacent to the point of interest in order to calibrate the software (ImageJ, Version 1.52a, NIH, USA). For image calibration, the millimetre markings on the graduated probe were linked together by a straight line to serve as a 100µm standard scale. Against this calibrated scale, the marginal misfit was calculated by drawing a straight line from the prepared margin to the crown boundary at the marked point of reference (Figure 2).

Data was analysed using SPSS 23. Descriptive statistics for marginal accuracy were calculated as mean $\pm$ standard deviation (SD). Shapiro-Wilk test was demonstrated that data was normally distributed. Independent t test was used to elucidate the difference in means between Protemp 4 and Integrity. One-way analysis of variance (ANOVA) was used to calculate the difference in means among the four walls and associated marginal misfit. To

analyse the two temporary crown materials against their four walls each, in order to check which margin exhibited the most gap, was determined using factorial design ANOVA. Post-hoc Tukey honestly significant difference (HSD) test was used for pairwise comparison. Intraclass correlation (ICC) was done using 10% of measurements to determine the inter-examiner reliability. $P < 0.05$ was kept as the level of significance.

Results

Mean marginal discrepancy for provisional crowns fabricated with Protemp 4 and Integrity was $410 \pm 222 \mu\text{m}$ and $319 \pm 176 \mu\text{m}$, respectively. The marginal discrepancy between the two groups was statistically significant ($p = 0.027$), with buccal margin exhibiting the most discrepancy ($p < 0.01$) (Table 1). Both the type of the provisional material and wall independently affected marginal discrepancy (Table 2). However, the interaction between the two factors did not significantly affect the results ($p > 0.05$). ICC indicated good reliability with 87% agreement between the two examiners.

Table-1: Mean marginal discrepancy of Protemp 4 and Integrity at the four walls of the preparation.

Marginal discrepancy (μm)	Material/ Wall	Buccal Wall	Mesial Wall	Lingual Wall	Distal Wall	Mean $\pm$ SD
	Protemp 4 (n=12)	582.7 ± 268.7	323.3 ± 160.9	331.7 ± 147.6	404.2 ± 207.2	410 ± 222
	Integrity (n=12)	438.3 ± 153.5	271.6 ± 173.3	232.5 ± 154.8	332.5 ± 167.8	319 ± 176
	p-value	$< 0.01^{**}$				0.27^*

* Independent sample t test, **One-way ANOVA. Significant p-value ≤ 0.05 . SD: Standard deviation.

Table-2: Effect of provisional crown bridge material, preparation wall and the interaction between the two on the marginal discrepancy.

Variables	p-value
Temporary Material	0.02
Preparation Wall	< 0.01
Temporary Material*Preparation Wall	0.84

Factorial analysis of variance (ANOVA), Significant p value ≤ 0.05 .

Discussion

The present study compared marginal accuracy of provisional crowns fabricated by two contemporary materials using the direct method.¹⁴ This method of fabrication is the one most commonly used in clinical practice. Results indicated that crowns fabricated with Integrity were more marginally accurate. Therefore, the null hypothesis that there is no difference in marginal accuracy in provisional crowns fabricated with Protemp 4

and Integrity crown and bridge material stands rejected.

The decision to remove flash and perform finishing with an abrasive disc prior to taking measurements was made to simulate in vivo conditions. It may be argued that removing flash with abrasive discs results in short margins which can then be repaired by adding compatible bisacryl material to the crown. However, the finishing process renders the temporary crown devoid of oxygen-inhibited layer. This, supplemented with contamination by oral fluids, results in a poor bond between the repair material and the provisional crown. It is, therefore, important that the provisional crown show good adaptation on its own.

Both materials exhibited some degree of marginal discrepancy, which is expected since resin materials exhibit polymerisation shrinkage. The American Dental Association states that film thickness for type I and II cements should not exceed 25µm and 40µm, respectively. Although aspirational, this level of marginal adaptation is rarely achieved in clinical settings.^{15,16} A more generally accepted limit of 120µm was proposed as the maximum tolerable marginal gap.¹⁷ Neither of the groups studied exhibited acceptable marginal accuracy as per these standards.

Dureja et al.¹¹ and Amin et al.¹² evaluated Protemp 4 for marginal misfit and found it to be 63.44µm and 71.59µm, respectively. Integrity has been a subject of observation by Adnan et al.³ and Givens et al.¹⁰, who concluded that the mean marginal discrepancy of temporary crowns fabricated with Integrity was 200µm and 218µm, respectively. The findings of the current study reported leakier margins than those previously stated; 410µm for Protemp 4 and 319µm for Integrity. The higher values may be in part due to the layer of separating media applied to allow easy separation of crowns from the abutment, which was not present in earlier studies.^{11,12} Amin et al.¹² utilised a stainless-steel abutment, in contrast to an ivory tooth that was used in most other studies yielding less irregular marginal finish.^{3,10,11} Lastly, as part of attempt in the current study to replicate in vivo conditions, the provisional crowns were slightly elevated and depressed to simulate direct technique, which allowed for dissipation of heat generated during the exothermic resin polymerisation reaction, as well as to prevent it from locking onto the abutment. The only other study that utilised this approach was by Givens et al.¹⁰ According to Tjan et al.¹⁸, this method of elevation and depression, or the on-off technique, resulted in the least marginally accurate crown margins. The use of separating media, manipulation of the provisional during setting, the material of the prepared abutment and finishing protocol all proportionally affect the final marginal accuracy.

A number of studies have evaluated marginal fit of temporary crowns over the years. Majority of these studies have chosen the midpoint of abutment surfaces as reference points for measurement.^{3,11,12,18} This is in line with the present study. However, most of these studies had small sample sizes and the inferences based on their results remain debatable. This may be offset by increasing the number of observations made. A total of 96 observations were made that showed the marginal gap in the two temporary crown materials. In the current study, the buccal surface exhibited the highest marginal inaccuracy. This is similar to earlier findings^{3,11}. However, most studies have not reported the leakiest margin.^{1,10,12,18-20} With polymerisation shrinkage being uniform on all surfaces, this may be attributed to the final removal of the provisional crown. The manual removal of the provisional crown is possible only in a buccolingual direction, with more force being generated on the buccal aspect of the crown. This may result in a plastic deformation along the margin that culminates into a greater marginal misfit along that wall. More evidence through future research needs to be generated to further corroborate these findings.

Provisional crowns with poor marginal accuracy require greater thickness of luting cement to compensate for the misfit. A thick cement layer may, however, lead to increased amounts of water sorption, which can adversely affect its mechanical properties.²¹ Rekow et al.²² further demonstrated that a thick layer of cement undergoes viscoelastic deformation when faced with cyclic loading. Therefore, trying to compensate for marginal inaccuracy using thick film thickness of temporary cements will not yield adequate results.

All provisional crowns in the current study were fabricated on a singular ivory tooth to minimise the chances of error during duplication of dyes. Surgical loupes were used to finish crown margins, instead of a dental operating microscope, to more closely mimic routine clinical practice. The effect of adjacent teeth on the accuracy of impression making and marginal fit was considered. Therefore, the preoperative impression was made with the dye screwed into place with adjoining teeth present. All samples of a group were fabricated and examined on the same day to ensure standardisation.

The in vitro nature of the current study was a limitation and may not exactly represent how these materials and processes interact in the oral environment. Besides, thickness of the separating media was not standardised and can be a possible reason for decreased marginal accuracy. Another possible limitation is that the provisional crowns in the study were not thermocycled.

As thermocycling is used primarily to age materials, the results of the study should be interpreted as being indicative of marginal accuracy of provisional crowns in the short term. Ideally, the gap should be measured over time to measure deterioration of the seal in the long term. Furthermore, the study used firm digital pressure, as opposed to a fixed mechanical force, for seating the crowns, as is done for patients within the clinic.

Conclusion

Provisional crowns fabricated using Integrity showed greater marginal accuracy than Protemp 4 crowns. The buccal margin of the prepared abutment was the least marginally accurate. Marginal accuracy was significantly affected by the type of provisional material and the margins of the preparation.

Disclaimer: The text was presented during the Academy of Ossosintegration's 36th Virtual Annual Meeting, March 12-14, 2021.

Conflict of Interest: None.

Source of Funding: None.

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