

Original Article

Evaluation of Vertical Marginal Adaptation of Provisional Crowns by Digital Microscope

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ABSTRACT

Objective: To investigate and compare the degree of vertical marginal discrepancy of four provisional crown materials by digital microscope. **Materials and Methods:** A total of 100 provisional crowns were fabricated on standardized resin dies by direct technique of provisional fabrication, using four different provisional materials ($n = 25$): Provisionals Fabricated by Systemp[®] c and b II, ivoclar vivadent, Schaan, Liechtenstein (group A); Protemp[™] Plus, 3M ESPE, Neuss, Germany (group B); Success CD, PROMEDICA, Neumunster, Germany (group C); and Trim[®] Plus, Bosworth Company, Illinois, USA (group D). The provisional crowns were finished, tried, and locked with a customized device under 15N of vertical axial force. The vertical marginal discrepancy between the crown margin and the resin die was measured in micrometers using digital microscope (KH-7700, Hirox-USA, Inc., NJ, USA) at mid of buccal, lingual, mesial, and distal margin areas by a trained technician. **Results:** The mean values obtained for each group were as follows: group A = 129.10 ± 41.64 , group B = 123.36 ± 40.94 , group C = 89.67 ± 25.34 , and group D = 107.24 ± 38.32 . Assessment by *post hoc* Tukey's test at 5% significance level showed a statistically significant difference ($P < 0.05$) between group C and group D with the other groups. Results of one-way ANOVA showed a statistically nonsignificant difference ($P > 0.05$) between the means of the four areas of measurement for each group. **Conclusion:** Marginal discrepancy of the group C (Success CD) was the lowest among the provisionals tested. The mean vertical marginal gap values for the materials tested were found to be within the clinically acceptable range ($<130 \mu\text{m}$).

KEYWORDS: Crowns, crown margins, marginal adaptability, provisional restorations, provisionals, temporary crowns

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INTRODUCTION

Provisionalization of the prepared teeth for crowns and bridges are an integral part of fixed prosthodontic treatment and are currently recognized to have a fundamental role in the determination of success or failure of permanent restorations. These provisional (temporary) crowns serve important roles during the treatment after the preparation of the teeth and until final cementation of the permanent crown or bridge. Marginal accuracy of provisional restorations is of paramount importance because an acceptable marginal fit maintains the gingival health and

protects the tooth from physical, chemical, bacterial, and thermal injuries. Poor marginal adaptation of provisional restorations increases plaque retention and changes the distribution of the microflora, which can induce the onset of gingival disease, leading to the complications during the subsequent treatment steps of fixed prostheses. The presence of marginal gaps in the provisional restorations exposes the temporary luting

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cement to the saliva and brushing intraorally. If the gap is large, the dissolution of cement in the oral fluids will also be fast.^[1-5]

The marginal fit or accuracy of a restoration can be defined best in terms of the “misfit” or the gap measured at various points between the restoration and the tooth. The vertical marginal gap measured in this study is the vertical distance measured parallel to the path of withdrawal of the provisional and the respective resin dies at mid of buccal, lingual, mesial, and distal sides. A marginal misfit can be considered acceptable when it is visually imperceptible or cannot be detected using a dental probe. A marginal gap of less than 80 μm is proven to be very difficult to detect clinically. Marginal gap values between 100 and 150 μm are considered clinically acceptable. However, difficult to detect they can be a source of housing for the bacteria ultimately leading to the inflammation of the gingiva around the margins.^[6-9]

The most common materials used for the fabrication of the provisionals are polymethylmethacrylate (PMMA) resins and composite-based resins (CBR). The PMMA comes in the form of polymer which is powder and monomer which is liquid and has to be hand mixed. The CBR comes in the form of auto-mixed paste to paste tubes. The PMMA is chemically polymerized whereas the CBR are available as chemically or light cured materials. A limited number of *in vitro* studies have been conducted to assess the degree of marginal gap formation of provisional materials. Results of these studies show contradicting results. Some studies indicate that monomethacrylates have lower marginal discrepancies compared to dimethacrylates, some of them show comparable fit between both the types, whereas one study shows bis-acryl composite resin to be superior to methacrylate resin. One of the inherent properties of polymer based interim materials is polymerization shrinkage, which causes dimensional changes that can adversely affect precise fit (marginal discrepancies and occlusal interferences) and lead to internal stresses within the restoration. Polymerization shrinkage, heat generation during polymerization, and monomer toxicity are some reasons because of the which the use of the PMMA these days is decreased.^[3-7, 10-12]

The purpose of this study was to investigate and compare the vertical marginal discrepancy measured by digital microscope, of four provisional crown materials; Systemp[®] c and b II, Ivoclar Vivadent, USA (group A); Protemp[™] Plus, 3M ESPE, Germany (group B); Success CD, PROMEDICA, Germany (group C); and Trim[®]Plus (group D), using the direct method of fabrication. The

null hypothesis was that there is no difference in the vertical marginal discrepancy of the different provisional materials.

MATERIALS AND METHODS

An *in vitro* method was used to simulate the direct technique of provisional crown fabrication in which the crown was fabricated directly on the duplicated resin die of a prepared tooth using a silicone putty index. An artificial ivorine mandibular right first molar #46 (KaVo Dental GmbH, Germany) was mounted on a resin base (Ortho-Resin, Degu Dent GmbH, Germany) of 2 × 2 cm, exposing the anatomic crown and 2 mm of the coronal root. A 2 × 2 mm square-shaped orientation groove was added on the lingual side of the base. A total of 100 silicone putty indexes (Ivoclar, Vivadent Inc., USA) were fabricated for the mounted tooth. The orientation groove served as a lock when the putty indexes were tried again on the tooth and also during the fabrication of the Provisionals [Figure 1]. These indexes were used for the fabrication of the provisional crowns by the direct technique. After the indexes fabrication, the tooth was prepared by one prosthodontist for an all-ceramic crown, according to current guidelines/recommendations. These included a 1 mm heavy chamfer with a smooth continuous gingival finishing line, a 5–10° combined convergence angle, 2 mm of occlusal reduction, 1 mm of axial reduction, and an overall rounded and smooth line angles.^[13,14] A silicone putty index (Ivoclar, Vivadent Inc.) of the tooth was recorded before the preparation of the teeth and was used to provide a mesiodistally sectioned index for verifying the preparation.

The preparation of the tooth was followed by recording 100 polyvinyl siloxane impressions (Virtual[®]380, Ivoclar, Vivadent Inc.) of the prepared tooth. All the impressions were examined visually for any defects and impressions with any defects were discarded. The impressions were then poured with resin (Ortho-Resin, Degu Dent GmbH) for the resin duplicates of the prepared tooth for the fabrication of samples for the study. All the duplicated resin samples were examined visually for any defects and samples with any defects were discarded and the impressions repoured.

Four different commercially available provisional crown materials were selected and groups were made [Table 1]. The duplicated resin dies were divided randomly into 25 resin dies per group. For each group provisional crowns were fabricated on the resin dies according to the manufacturer’s instructions of the materials, using the silicone putty indexes fabricated before the preparation of the tooth by direct technique.^[1]

For the groups A, B, and C, the material was dispensed directly into the Putty Index from the cartridge by means of an auto mixing tip using a dispensing gun for the same brand. The loaded putty index was placed onto the die and the positioning was verified correctly with the help of the square-shaped orientation groove. After complete polymerization of the material and the time elapse per manufacturers instructions, the crown was removed and checked for irregularities and voids. For the group D (PMMA), first liquid (3 mL) was put in a mixing cup and then powder (6.3 g) was added and hand mixed. This was then poured in the putty index. When the material got dull the putty index was seated onto the die and position secured with the help of the square shaped orientation groove. The putty index was left for around 2 min. Then it was elevated and resealed on the die to simulate the direct technique.

After the complete setting of the provisional materials, they were removed from their respective dies. The intaglio surface of the crown margin was marked with a lead pencil. The provisionals were finished with acrylic burs (H79E040, All purpose E-Cutter system, Dental Instrumentation, Brasseler, USA) using a low-speed straight hand piece (KaVo Dental, GmbH, Biberach, Germany). During the finishing, the intaglio surface of the crown was kept in front of the eyes and the surface of the crown margin marked with the pencil served as a reference and was not trimmed by the burs. This was to make sure no marginal gap was produced because of the trimming. The samples were then tried according to the visual criteria. Any sample that was over trimmed during the finishing were discarded and rejected. The samples with no gaps according to visual criteria were accepted [Figure 1]. This procedure was repeated for all crowns. The samples were prepared for each group ($N = 25 \times 4$; 100 provisionals) [Figure 2]. All the samples were then placed in distilled water at room temperature for 24 h.

A customized device was fabricated within which a Manual Torqueing Wrench (Manual Torque Wrench Prosthetic, Nobel Bio Care, Switzerland) was used for application of a vertical force of 15N over the provisional crown onto the resin die and to keep the provisional locked in this position with the help of customized lock [Figure 3].

The vertical marginal gap between the crown margin and the die was recorded with digital microscope (Digital Microscope, KH-7700, Hirox-USA, Inc.). The vertical distance from the external crown margin to a perpendicular corresponding point on the margin of the die was measured with the help of a micrometer ruler placed in the field of view to calibrate the computer software program [Figure 4]. The measurements were recorded by a trained digital microscope technician and verified by another technician to avoid any measurement errors. A total of four measurements at mid of buccal, mesial, distal, and lingual surfaces for each sample were recorded in micrometers.

The data were entered in SPSS version 22 (SPSS, Inc., Chicago, IL, USA). The mean values of the vertical marginal discrepancy were calculated for each group of materials for the four sites measured as shown in [Table 2]. One-way ANOVA test was carried out to determine whether there was a difference between the four groups of materials and within each of them. Multiple comparisons between the materials were carried out using *post hoc* Tukey's tests. The probability for statistical significance was set at $\alpha < 0.05$.

RESULTS

The overall mean gap values for the four groups are presented in [Table 2]. Group C (Success CD) showed the



Figure 1: Prepared sample with orientation groove in the base

Table 1: Grouping of the 4 provisional crown materials

Name of the provisional material	Group	Composition of the material	Manufacturer
System® c and b II	A	Polyfunctional methacrylates	Ivoclar Vivadent, Schaan, Liechtenstein
Protemp™ 4	B	Multifunctional methacrylates	3M ESPE, Neuss, Germany
Success CD	C	Methacrylates	PROMEDICA, Neumunster, Germany
Trim®Plus	D	Polymethylmethacrylate	Bosworth Company, Illinois, USA

Table 2: Mean values plus ANOVA results between four sites of measurements for each material

Group	Site	N	Mean ^a	SD	95% Confidence interval for mean		ANOVA <i>P</i> -value
					Lower bound	Upper bound	
A	Buccal	25	126.05	44.24	107.79	144.31	0.583
	Distal	25	121.38	41.11	104.41	138.36	
	Lingual	25	132.18	43.04	114.41	149.95	
	Mesial	25	136.79	38.87	120.74	152.83	
	Total	100	129.10	41.64	120.84	137.36	
B	Buccal	25	131.86	42.24	114.42	149.30	0.530
	Distal	25	120.20	48.57	100.15	140.25	
	Lingual	25	115.50	36.15	100.58	130.42	
	Mesial	25	125.88	36.18	110.94	140.82	
	Total	100	123.36	40.94	115.24	131.49	
C	Buccal	25	92.43	27.67	81.01	103.85	0.105
	Distal	25	84.90	18.42	77.30	92.51	
	Lingual	25	82.79	15.42126	76.42	89.15	
	Mesial	25	98.55	33.81	84.60	112.51	
	Total	100	89.67	25.34	84.64	94.70	
D	Buccal	25	103.40	57.65	79.60	127.20	0.124
	Distal	25	122.86	22.72	113.48	132.25	
	Lingual	25	103.40	23.56	93.68	113.13	
	Mesial	25	99.30	36.23	84.34	114.25	
	Total	100	107.24	38.32	99.64	114.85	

^aMean gap was measured in micrometers

Table 3: Comparisons of the means of gap between four types of provisional material by *post hoc* Tukey

Groups	A	B	C	D
A	0	0.693	0.000	0.000
B	0.693	0	0.000	0.012
C	0.000	0.000	0	0.005
D	0.000	0.012	0.005	0

P value was significant at $P < 0.05$



Figure 2: Samples of one group of materials

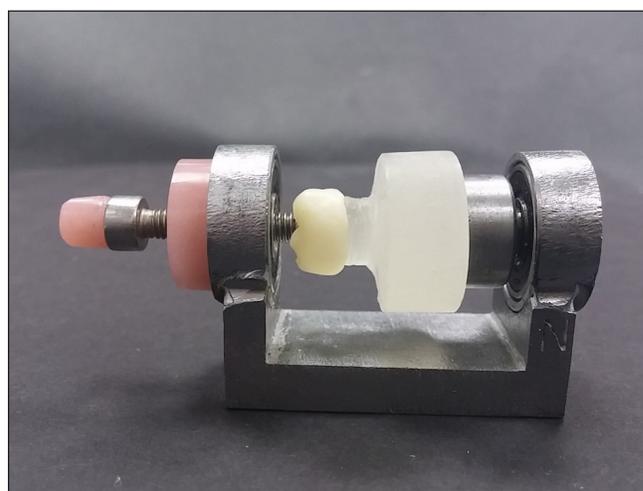


Figure 3 : Customized locking device with the sample locked

lowest and the group A (Systemp[®] c and b II) showed the highest mean gap values out of the four groups. Assessment by *post hoc* Tukey's test showed a statistically significant

difference ($P < .05$) between the group C with the other groups and also group D (Trim[®] Plus) with the other groups [Table 3].

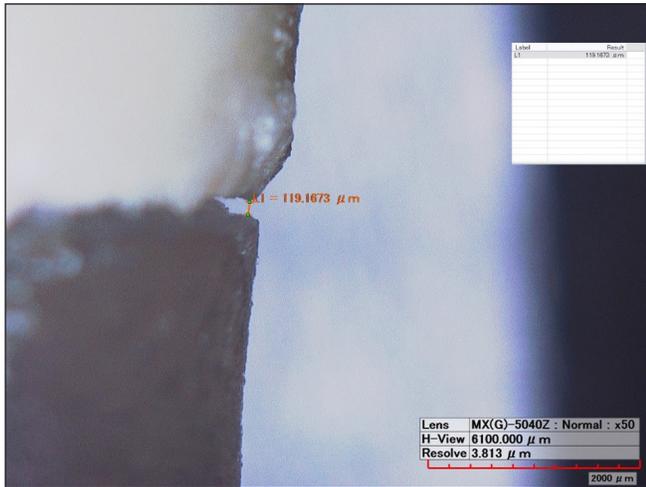


Figure 4 : Digital microscopic measurements of one area of a sample

[Table 4] shows the mean values for the four groups and overall mean values of the gap thickness at different areas of measurements. Results of one-way ANOVA showed a statistically non-significant difference between the means of the four areas of measurement for each group.

Multiple comparisons with *post hoc* Tukey's test revealed a statistically nonsignificant difference between the mean values of buccal, distal, lingual, and mesial areas of measurements [Table 5].

[Figure 5] describes the differences in the mean values for the four groups at four evaluated regions obtained with digital microscope. The highest difference among the groups was found in the lingual region and the least difference was found in the distal region.

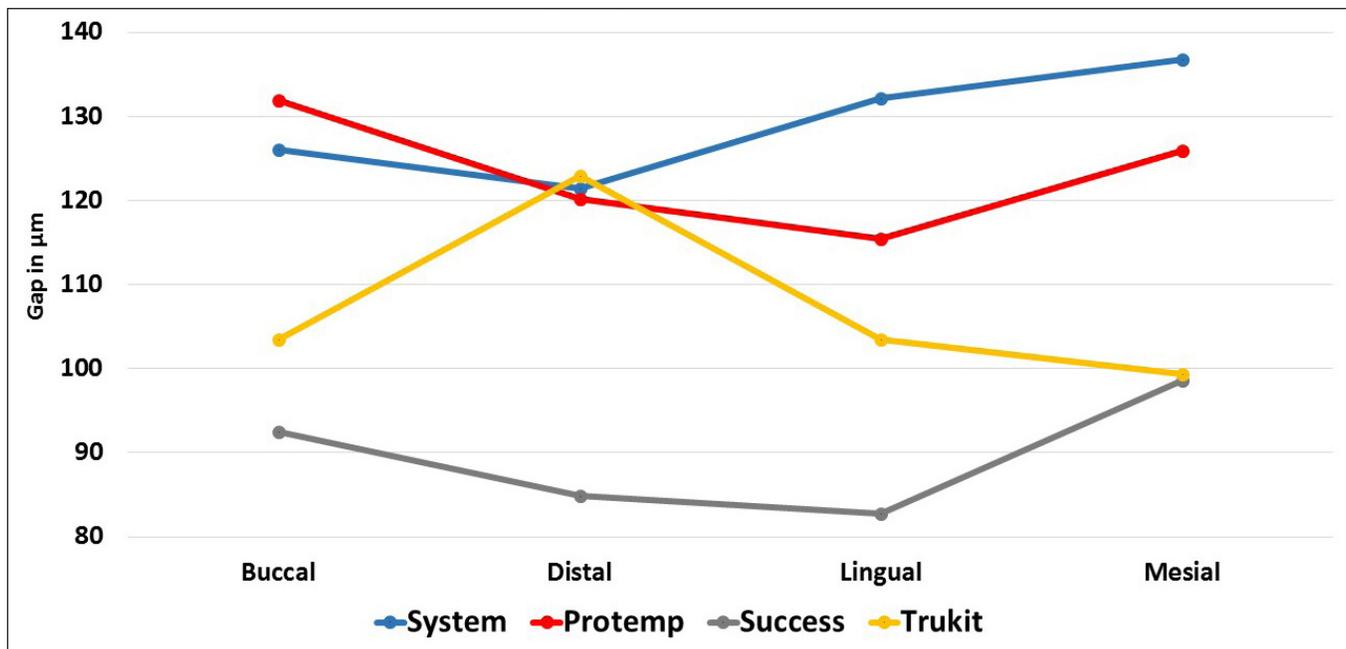


Figure 5: Mean values for vertical marginal gaps for four groups in four areas

Table 4: Mean values plus ANOVA results between four sites of measurements

Site of marginal gap	Mean ^a	SD	95% Confidence interval for mean		ANOVA P-value
			Lower bound	Upper bound	
Buccal (n = 100)	113.44	46.49	104.21	122.66	0.685
Distal (n = 100)	112.34	37.99	104.80	119.88	
Lingual (n = 100)	108.47	35.85	101.35	115.58	
Mesial (n = 100)	115.13	39.49	107.29	122.97	
Total (n = 400)	112.35	40.08	108.40	116.28	

^aMean gap was measured in micrometers

Table 5: Comparisons of the means of gap between four sites of measurements by post hoc Tukey test

Groups	Buccal	Distal	Lingual	Mesial
Buccal	0	0.997	0.779	0.988
Distal	0.997	0	0.881	0.951
Lingual	0.779	0.881	0	0.582
Mesial	0.988	0.951	0.582	0

P value was significant at $P < 0.05$

DISCUSSION

In this study, the marginal adaptation of the single unit provisional restorations fabricated from four different commercially available provisional restorative materials on a standardized duplicated resin die of a prepared tooth was investigated. The aim of the study was to determine the vertical marginal gap between the provisional crown and the finish line of the prepared tooth at four different areas. The reason to evaluate the marginal gap after the fabrication of provisional and before its cementation was to avoid the influence of the temporary cement and cement thickness. It was assumed that the temporary luting cement would have increased the vertical marginal gap and in this way the inherent property of each material could not be tested. This method of testing the materials was also employed by Amin *et al.*^[1] Although this *in vitro* study may not reflect the oral conditions, vertical marginal gap values recorded could be a useful predictor of clinical performance and helpful for comparing provisional materials tested in a controlled situation.

This study was an attempt to test the vertical marginal gap values of the different provisional materials using same standardized dies and also following the manufacturer's instructions. Like any *in vitro* study, there were some limitations, which may have affected the marginal gap, like finishing of the provisionals after the complete curing, vertical force applied to keep the provisional intact over the respective die and the measurements under the digital microscope. However, an attempt was made to address to each of the individual issues. The provisional crown margin was marked with a lead pencil and during the finishing it was kept as a reference to make sure it was not touched by the finishing bur. A customized locking device was used within which a vertical force of 15N was applied with a Manual Torqueing Wrench (Manual Torque Wrench Prosthetic, Nobel Bio Care) and the sample was locked in this position. The Microscopic measurements were also verified by another microscope technician. Multiple comparisons between the sites of the measurement (buccal, distal, lingual, and mesial) also showed a statistically nonsignificant difference. This also indicates that the standardization between the preparation of the samples.

There is no universally accepted protocol to access and measure the marginal gap of dental restorations. In this study, measurements were recorded with a digital microscope. During the recording of the measurements, the provisional was positioned over the respective dies under a constant load using a customized device and secured in its position with a locking screw. Use of this customized device for securing the provisional under a standard load, whereas the measurements were recorded was something unique with in this study. The limitation of using this technique is that it gives a two dimensional view for measuring the marginal gap and do not examine three-dimensional adaptation.

Although various studies have reported the marginal gap values of the different provisional materials, the results of all these studies are difficult to interpret and compare with the results of the current study, because of the variations in the sample size and difference in the methods used for the measurements.

Conventional PMMA (group D) should be hand mixed with proper ratio of powder and liquid and allowed to reach the desired consistency before placement on tooth preparation. Removal of these interim restorations at the appropriate time to limit distortion and allow complete polymerization prior to finishing is crucial for making an accurate interim restoration. Young *et al.*^[10] showed that composite resin material (groups A–C) was superior to auto polymerizing PMMA because of its lower polymerization shrinkage and lack of exothermic reaction. In this study, the PMMA resins (group D) produced comparable rather better marginal fit than some of the composite provisional materials (groups A and B). In a study by Nejatidanesh *et al.*,^[7] the composites, polyethylmethacrylate (PEMA), and vinyl ethylmethacrylates (VEMA) resins produced comparable marginal fit. In another study by Tjan *et al.*,^[9] PEMA and composites recorded best marginal adaptations. One of the possible reasons for better marginal adaptation of the auto polymerizing PMMA resins in this study, possibly could be following the manufacturer's instructions (Trim® Plus). Mixing and handling of auto polymerizing PMMA resins needs expertise. Improper handling of this materials results in more distortion.

According to the results of this study, group C (Success CD) which by composition written in the manufacturers literature is methacrylates showed better marginal adaptation among the other polyfunctional (group A) methacrylates, multifunctional (group B) methacrylates, and the PMMA (group D) resins. One possible explanation for the better results of the Success CD could be that it is a difunctional methacrylates resin chemically (as not mentioned by the manufacturer) compared to the other materials that are poly/multifunctional

methacrylates. The difunctional methacrylates has two methacrylate groups at each end of the monomer molecule compared while the poly/multifunctional methacrylates can have more than two methacrylate groups at each end of monomer molecule.

Several authors have considered a marginal discrepancy between 50 and 120 μm to be in a range of clinical acceptance.^[15-17] In this study, the mean of the buccal, distal, lingual, and mesial marginal gap was 113.44, 112.34, 108.47, and 115.13 μm , respectively. This finding is in line compared to the results of other studies which are within the range of 120 μm . The variations in the results of this study with the other studies could be because of the difference in the materials used and the difference in the fabrication techniques. With this variation we can also predict that a certain percentage of variation in the fit of provisional exists in clinical cases and is difficult to predict clinically.

Amin *et al.*^[1] reported that the marginal fit of the provisionals is also affected by the time elapsed after mixing of the materials. Karaokutan *et al.*^[3] has also reported that physical changes may occur, which affects the mechanical properties of the provisional materials if they are exposed to temperature changes or kept dry. To avoid these complications, all the samples of this study were placed in distilled water at 37°C for 24 h before the microscopic examination.

Over a period of time, the provisional crowns have a tendency for increase in the marginal gaps. With the availability of the different materials and brands in the market, each of the provisional material should be evaluated individually for the marginal gap opening intraorally. This study attempted to highlight some of the issues related to the marginal opening of the provisional materials available in the market. However, further studies and clinical trials are recommended and needed for the development of more durable and marginally fit provisional materials. This may help the clinicians during the temporization of the prepared teeth.

CONCLUSIONS

Within the limitations of the study it can be concluded that

1. marginal discrepancy of the success CD (composition) was the lowest than those of the 3 other provisionals tested;
2. the mean vertical marginal gap values for the four materials tested were found to be within the clinically acceptable range (<130 μm); and
3. the marginal gap values for the PMMA resins (group D = 107.24 μm) were found to be

marginally better than the composite materials (group A = 129.10 μm and group B = 123.36 μm).

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Conflicts of interest

There are no conflicts of interest.

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