ORIGINAL ARTICLE

Surface roughness differences of bis-acryl provisional crown material under different toothbrush filament and toothpaste abrasive degree: a laboratory experimental study

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ABSTRACT

Introduction: Brushing of provisional crown material using a toothbrush and abrasive toothpaste induces surface roughness. This study, therefore, aims to determine the difference in surface roughness on provisional crown materials after brushing with soft and medium filament toothbrushes using high and low abrasive toothpaste. **Methods:** This type of laboratory experimental research employed a pre-test and post-test group design of 40 samples divided into four groups of ten samples each. The groups consisted of Group A (bis-acrylic temporary crown material brushed with medium-filament toothbrush and high-abrasive toothpaste), Group B (bis-acrylic temporary crown material brushed with soft-filament toothbrush and high-abrasive toothpaste), Group C (bis-acrylic temporary crown material brushed with medium-filament toothbrush and low-abrasive toothpaste), and Group D (bis-acrylic temporary crown material brushed with soft-filament toothbrush and low-abrasive toothpaste). The sample brushing method was carried out using a Modified V8-Brushing Machine tool for 2000 cycles at a speed of 120 cycles/minute and a 0.2 N pressure. **Results:** A profilometer was used to measure surface roughness. The mean value of surface roughness was analyzed by a univariate test, yielding groups A (0.41 µm ± 0.18), B (0.36 µm ± 0.13), C (0.40 µm ± 0.15), and D (0.25 µm ± 0.09). The Kruskal-Wallis Statistical analysis test determined significant differences among test groups. This study indicates that the surface roughness of bis-acryl provisional crown material brushed with soft and medium-filament toothbrushes differed from that with a combination of high and low-abrasive toothpaste $p = 0.001$ ($p < 0.05$). **Conclusion:** Brushing provisional crown materials with a medium-filament toothbrush resulted in a higher roughness value than with a soft-filament toothbrush, and the group that brushed with high-abrasive toothpaste showed higher roughness values than that with low-abrasive toothpaste.

KEYWORDS

bis-acryl, surface roughness, toothbrush filament, abrasive toothpaste

INTRODUCTION

A provisional crown is an artificial crown that is temporarily fitted prior to the placement of a definitive crown.[1] Bis-acryl composite resins were introduced to overcome the negative effects of methacrylate in acrylic resins. Bis-acryl composite resins consist of bi-functional substrates to provide cross-linking with each other and monomers that lead to improved impact strength and robustness.[2] This material contains inorganic fillers that are expected to reduce polymerization shrinkage and exothermic reactions. However, it has the disadvantages of high cost, brittleness, poor polishing ability and difficulty in reassembly.[3]

Provisional crowns installation is inseparable from the need to pay attention to the hygiene of provisional crowns, whether the provisionalization is short-term or long-term. Brushing is the most common measure of oral hygiene and is a daily habit even when a person using provisional crown.[4] The time spent for tooth cleaning activity will have an impact on the provisional crown.[5] The activity may lead to an increase in the surface roughness of the provisional crown.[6] Moreover, the surface roughness of the provisional crown caused by brushing will increase plaque retention. Plaque formation and adhesion of certain microorganisms on provisional crowns can be a major cause of oral diseases such as caries, periodontal infection, and gingival inflammation.[7] Surface roughness is an irregularity of a surface that can be influenced by many things, including filaments from toothbrushes and silica in toothpaste.[6,8]

In general, toothbrush filaments are divided into three types based on the degree of fineness and stiffness: soft, 0.2 mm diameter, medium, 0.3 mm diameter, and hard, 0.4 mm diameter.[6,8] Cleaning action with different filament variations can have different abrasion impacts.[9] The use of toothpaste also affects the surface of the provisional crown.[10] Toothpaste serves as a carrier for active ingredients for therapeutic or cosmetic purposes, and inactive ingredients such as detergents.[11] Commonly used abrasives are hydrated silica, calcium carbonate, dicalcium phosphate, calcium pyrophosphate, alumina, perlite, and sodium bicarbonate.[12] The abrasiveness level of toothpaste is known as RDA (Relative dentin

abrasivity). Based on the RDA value, toothpaste has a level of abrasiveness, namely high abrasive, medium abrasive, and low abrasive.[13]

Based on previous research, it is stated that brushing on provisional crown material using a soft-filament toothbrush and high-abrasive toothpaste showed an increased roughness value compared to brushing with a medium-filament toothbrush and high-abrasive toothpaste.[14] Meanwhile, another study stated that brushing using a soft toothbrush combined with low abrasive toothpaste showed no significant relationship between the abrasion process and surface roughness on composite resin-based provisional crown materials.[15] It can be hypothesized that the surface roughness value of provisional crown material will increase after being brushed with a combination of soft and medium filament-toothbrushes and high and low-abrasive toothpaste. This study therefore, aims to determine the difference in surface roughness on provisional crown materials after being brushed with soft and medium-filament toothbrushes and high and low-abrasive toothpaste.

METHODS

Type of experimental laboratory research used the Pre-Test And Post-Test Group Designs. A total of 40 samples was determined using the sample size formula for the hypothesis test of the difference between the means of two independent groups. The following materials and compositions used in this study are shown in Table 1.

Table 1. Material composition of temporary crown, toothbrush, toothpaste

Material	Composition	Lot Number
Provisional crown material	Bis-acryl resin material	2132621326
Smartempt®, USA	Divinyl methacrylate, amine organic, peroxide organic, nanofiller	
Toothbrush filaments		
Soft filament toothbrush*	Acrylonitrile Styrene, Nylon, Size 0,2 mm	89934101365
Medium filament toothbrush*	Acrylonitrile Styrene, Nylon Size 0,3 mm	89934101365
Abrasive toothpaste		
High abrasive toothpaste**	Hydrogen Peroxide and Silica	2068CH12F2
Low abrasive toothpaste**	Calcium Carbonate and Silica	2147CN12V3

*Omica, Jakarta, Indonesia., **Colgate Optic White Sparkling White®, USA.

The research procedures were conducted through preparation, making 40 samples, polishing procedures, brushing samples, surface roughness testing, data processing, and analysis.The seat was manufactured by producing 40 units of self-polymerized acrylic resin material blocks using a 12x20x10 mm mold. A cavity (10 mm in diameter and 2 mm deep) was prepared in the self-polymerized acrylic resin material block to receive the temporary material. Bis-acryl material was applied into the cavity; hence, celluloid strips and glass slabs were placed onto the mold surface, adjusted to polymerization time. Thus, after polymerization stage, a polishing procedure was performed to all samples using rotary grinder under #1000 and #1200 abrasive paper grit number to standardize the sample surface prior to surface roughness testing. Samples were immersed in distilled water for 24 hours at room temperature.

In this study, the sample brushing procedures were done using the V8-Brushing Machine Modified. Each sample went through 2000 brushing cycles, which was equal to for minutes, twice a day A speed level of 120 cycles/minute and toothbrush pressure of 0.2 N were applied during the brushing process. The brushing process began with fixation of all samples and toothbrushes on V8-Brushing Machine Modified. Slurry toothpaste was prepared from a mixture of toothpaste and distilled water in a 1:1 ratio. Hence, the slurry toothpaste was inserted into a tube and fixed onto the brushing machine. Each toothbrush was only used for one sample. After treatment, the samples were washed under running water and dried. The study consisted of four treatment groups (Table 2).

Figure 1. Fixation of samples and toothbrushes on V8-Brushing Machine Modified (A), Toothpaste slurry is put into the tube, and fixation of the tube to V8-Brushing Machine Modified (B), Brushing process of each different sample using a combination of a medium-filament toothbrush and a soft-filament toothbrush, and with high-abrasive and low-abrasive levels of toothpaste (C)

Table 2. Treatment group of temporary crown materials brushed with soft and medium-filament toothbrushes using high and low-abrasive toothpastes

Material	n	Treatment			
		High abrasive toothpaste (Colgate Optic White Sparkling White®, USA)		Low abrasive toothpaste (Colgate maximum protection®, USA).	
		Medium filament	Soft filament	Medium filament	Soft filament
Bis-acryl (Smartempt®, USA)	40	A	B	C	D

A profilometer was used to measure the surface roughness of bis-acryl is (Mitutoyo, Tokyo, Japan). The sample surface with a 0.25 mm/s each was scanned by using a stylus. . Profile scanning started at a distance of 0.5 mm from the predefined area. Measurements were made three times and then the average value was calculated.

The results of surface roughness measurements were processed and analyzed using SPSS version 22. The normality test was done using the Shapiro Wilk test ($p < 0.05$). Then the Kruskal-Wallis test ($p < 0.05$) was carried out to evaluate the significant differences in surface roughness values among tested groups.

RESULTS

The results of surface roughness measurements in the four groups brushed with a variety of filament toothbrushes before and after brushing can be seen in Figure 2.

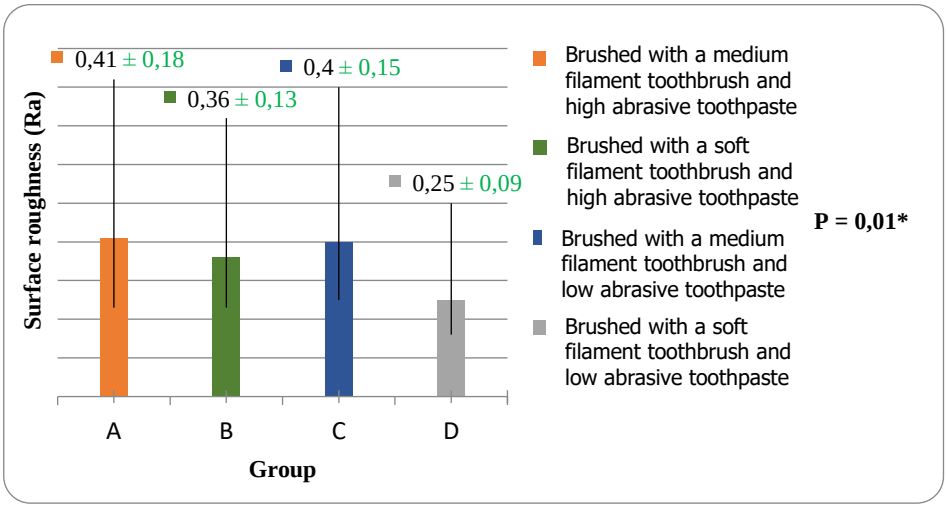

Figure 2. Surface roughness means, standard deviation, and significant test in each group (in µm)

The results of the study as depicted in Figure 2 show the mean value and standard deviation of surface roughness in each group after brushing the provisional crown material. The mean value of surface roughness in the group brushed with a medium-filament toothbrush has a higher mean rate than that with a soft-filament toothbrush. The group brushed with high-abrasive toothpaste also has a higher mean value surface roughness compared to the group brushed with low abrasive toothpaste. The Kruskal-Wallis statistical analysis test was used on normally distributed data to determine significant differences between test groups. The test showed a significance $p = 0.01$ which indicates that there is a significant difference in surface roughness among the four groups tested. (Figure 2.)

DISCUSSION

A toothbrush is a tool used for cleaning teeth. However, toothbrush use can cause abrasion on the teeth and provisional crown materials.[8] This study discovered that the roughness value of soft-filament toothbrushes was lower than that of medium-filament toothbrushes, and the group brushed with low-abrasive toothpaste had a lower surface roughness value compared to that with high abrasive toothpaste. These are in accordance with the research of Jeong et al[16], which stated that brushing with a soft-filament toothbrush produced a lower surface roughness value than brushing with a medium-filament toothbrush. This result might occur because soft-filament toothbrushes have the capability to spread small amounts

of toothpaste. Thus, even though the abrasive materials has a longer contact duration and larger contact area, they can only cause less abrasion on the sample.

This study has proven the effect of filament size on the abrasion process and surface roughness. A medium-filament toothbrush has a stiffer and thicker filament structure (0.3 mm). This stiffer filament is able to brush a larger area which implies a larger eroded area, compared to a softer filament toothbrush. Meanwhile, a soft-filament toothbrush is made of nylon-composed filament with a thinner filament structure (0.2 mm). It also has tighter filament which is only able to spread a smaller amount of toothpaste. These factors resulted in smaller abrasion effect.[10] The abrasion process that occurs on provisional crowns can be caused by pressure and friction during brushing; this will cause detachment of the resin matrix and filler material, resulting in surface roughness.[17]

The surface roughness values in group A (group of bis-acryl provisional crown material brushed with a medium-filament toothbrush and high-abrasive toothpaste) and C (group of bis-acryl provisional crown material brushed with a medium-filament toothbrush and low-abrasive toothpaste) are higher compared to surface roughness values in group B (group of bis-acryl provisional crown material brushed with a soft-filament toothbrush and high-abrasive toothpaste) and D (group of bis-acryl provisional crown material brushed with a soft-filament toothbrush and low-abrasive toothpaste). This is in accordance with the study of Zairani et al[10], which discovered that the increase in surface roughness of provisional crown material brushed with a medium-filament toothbrush was higher compared to soft-filament toothbrush. This condition can be caused by the thicker and stiffer structure of the medium filament. The filament causes breaks between the resin matrix bond and filler, which then cause abrasion to the surface roughness of the provisional crown material.[10]

The third highest surface roughness value in this study was found in group B (group of bis-acryl provisional crown material brushed with a soft-filament toothbrush and high-abrasive toothpaste). Group B (group of bis-acryl provisional crown material brushed with a soft-filament toothbrush and high-abrasive toothpaste) is not larger than groups A (group of bis-acryl provisional crown material brushed with a medium-filament toothbrush and high-abrasive toothpaste) and C (group of bis-acryl provisional crown material brushed with a medium-filament toothbrush and low-abrasive toothpaste). Additionally, this study discovered that group D (group of bis-acryl provisional crown material brushed with a soft-filament toothbrush and low-abrasive toothpaste) showed the lowest value of surface roughness of all groups. The surface roughness (Ra) value in group D is also indicated as the lowest abrasive level. The provisional crown is able to maintain better surface roughness and abrasive resistance.[17]

The increase in surface roughness of bis-acryl provisional crowns may be influenced by abrasive materials in toothpaste. Previous studies have shown that brushing the restoration surface using toothpaste for one hour could cause more abrasion than brushing with water for 6 hours. This study suggested that the type of toothpaste is an important factor in contributing to the damage to the provisional crowns surface. If the abrasion process continues, it can cause surface damage to the provisional crown material.[14] Based on previous research, abrasives in higher abrasive toothpastes was believed to show the presence of spherical silica particle clusters and various rhombohedral sizes above 50 µm, which can increase surface damage to provisional crown materials. The combination of abrasives and pressure during brushing can cause detachment or disconnection between the matrix and filler. Filler that has lost support will be eliminated easily and will leave a free-resin layer that will be abraded quickly if the process continues.[13]

Low abrasive toothpaste containing Calcium Carbonate and Silica abrasives allows for less abrasion, which is only on the superficial surface of the provisional crown material.[18] The results of the study in groups C (group of bis-acryl provisional crown material brushed with a medium-filament toothbrush and low-abrasive toothpaste) and D (group of bis-acryl provisional crown material brushed with a soft-filament toothbrush and low-abrasive toothpaste) using low-abrasive toothpaste showed a lower level of abrasiveness, but the use of different toothbrush filaments can still cause surface roughness on provisional crowns. Study of Lippert et al. stated that the use of low abrasive toothpaste with Calcium Carbonate content resulted in lower surface loss than the use of high abrasive toothpaste. This is because low-abrasive toothpaste can only erode the superficial layer of softened dentin, while high-abrasive toothpaste is more likely to affect the internal dentin structure.[18] In this study, the hypothesis was accepted, indicating that there is a difference in the surface roughness of bis-acryl provisional crown materials brushed with high and low-abrasive toothpaste using soft and medium-filament toothbrushes.

This study shows that the use of medium-filament toothbrushes and high-abrasive toothpaste should be avoided and instead suggests a combination of soft toothbrush filaments with low-abrasive toothpaste. This is because the average surface roughness value of bis-acryl temporary crown material in the combination group of medium-filament toothbrush and high-abrasive toothpaste is the highest among all the groups tested. This is necessary to avoid the effect of abrasion on the temporary crown material.

Increased surface roughness of provisional crowns is susceptible to discoloration, which will result in decreased aesthetics, plaque accumulation leading to secondary caries and periodontitis lesions. This will affect the aesthetic aspect of the patient wearing the provisional crown material. A prolonged process of roughness on the surface of the provisional crown material will result in reduced occlusal contact on the patient's antagonistic teeth.[19,20]

CONCLUSION

The bis-acryl temporary crown material group brushed with a medium-filament toothbrush resulted in a higher roughness value than the bis-acryl temporary crown material brushed with a soft-filament toothbrush, and the bis-acryl temporary crown material group brushed with high-abrasive toothpaste showed higher roughness values than brushing with low-abrasive toothpaste.

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