การประเมินความหยาบพื้นผิวของเรซินคอมโพสิตชนิดบัลค์ฟิลล์ ภายหลังการขัดด้วยระบบขัดที่แตกต่างกัน

Evaluation of Surface Roughness of a Bulk-Fill and a Conventional Resin Composite after Finishing and Polishing with Different Polishing Systems

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บทคัดย่อ

วัตถุประสงค์ของการศึกษา 1. เพื่อเปรียบเทียบความหยาบพื้นผิวของเรซินคอมโพสิตชนิดบัลค์ฟิลล์และเรซินคอมโพซิตชนิดดั้งเดิมภายหลังการขัดด้วยระบบขัด Optidisc™ หรือ Enhance™/Pogo™ โดยนำชิ้นงานเรซินคอมโพสิตที่ได้จากแบบหล่อโลหะเหล็กกล้าไร้สนิมรูปทรงสี่เหลี่ยมขนาด 5x5x2 ลบ.มม.60 ชิ้น มาแบ่งออกเป็น 4 กลุ่มๆละ 15 ชิ้น หลังจากขัดด้วยระบบขัดแล้วนำชิ้นงานไปวัดค่าความหยาบพื้นผิวด้วยเครื่องวัดความหยาบพื้นผิว ผลการศึกษาพบว่า ค่าเฉลี่ยความหยาบพื้นผิวเรซินคอมโพสิตที่ต่างชนิดกันไม่ว่าจะขัดด้วยระบบขัด Optidisc™ หรือระบบขัด Enhance™/Pogo™ มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) เรซินคอมโพสิตชนิดบัลค์ฟิลล์ที่ขัดด้วยระบบขัดที่แตกต่างกันมีค่าเฉลี่ยความหยาบพื้นผิวที่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) อย่างไรก็ตาม เรซินคอมโพสิตชนิดดั้งเดิมที่ขัดด้วยระบบขัดที่แตกต่างกันมีค่าเฉลี่ยความหยาบพื้นผิวที่แตกต่างกันอย่างไม่มีนัยสำคัญทางสถิติ ($p > 0.05$) สรุปได้ว่า 1. เรซินคอมโพสิตชนิดดั้งเดิมให้ค่าความหยาบพื้นผิวที่น้อยกว่าชนิดบัลค์ฟิลล์ 2. ระบบขัดทั้งสองระบบให้ค่าความหยาบพื้นผิวที่แตกต่างกันอย่างมีนัยสำคัญทางสถิติเฉพาะเรซินคอมโพสิตชนิดบัลค์ฟิลล์ 3. เรซินคอมโพสิตชนิดบัลค์ฟิลล์ที่ขัดด้วยระบบขัด Optidisc™ ให้ค่าความหยาบพื้นผิวที่น้อยกว่าระบบขัด Enhance™/Pogo™ ในขณะที่เรซินคอมโพสิตชนิดดั้งเดิมที่ขัดด้วยระบบขัดที่แตกต่างกันให้ค่าความหยาบพื้นผิวที่แตกต่างกันอย่างไม่มีนัยสำคัญทางสถิติ

คำสำคัญ: *เรซินคอมโพสิตชนิดบัลค์ฟิลล์ ระบบขัดแต่งรูปร่าง ระบบขัดเงา เรซินคอมโพสิต ความหยาบพื้นผิว*

Abstract

The objective of this study was to compare the surface roughness between bulk-fill (Sonicfill™) and conventional (Premise™) resin composite after finishing/polishing with Optidisc™ system (Kerr, USA) or Enhance™/Pogo™ system (Dentsply, USA). Sixty specimens of square-shaped resin composites are made from stainless steel molds size 5x5x2 mm^3. The specimens were divided into 4 groups (n=15). After polishing procedures, surface roughness (Ra) values were evaluated by a profilometer. From mean surface roughness values, statistically significant differences were found between two resin composites polished by either Optidisc™ system or Enhance™/Pogo™ system ($p < 0.05$) Statistically significant differences were also found in Sonicfill™ when polished with different finishing and polishing systems ($p < 0.05$). However, no difference was detected in Premise™ when polished by different finishing and polishing systems ($p > 0.05$). In conclusion, 1. Premise™ showed lesser surface roughness than SonicFill™. 2. Two finishing and polishing systems provided significantly different surface roughness value for only SonicFill™. 3. Finishing and polishing SonicFill™ with Optidisc™ system provided less surface roughness compared to Enhance™/Pogo™ system while finishing and polishing Premise™ with either system provided no different surface roughness.

Keywords: *Bulk-fill, Finishing, Polishing, Resin composite, Surface roughness*

1. Introduction

Nowadays, resin composites are widely used for direct restoration of both anterior and posterior teeth. Because of their excellent characteristics, such as mechanical properties, manipulative qualities, esthetic properties and biological compatibility (Karbhari & Strassler, 2007; Musanje & Ferracane, 2004; Xia, Zhang, Xie, & Gu, 2008).

However, resin composites also have disadvantages such as polymerization shrinkage which cause the movement of cusps, debonding or enamel cracks, microleakage, postoperative sensitivity and secondary caries (Park, Chang, Ferracane, & Lee, 2008). Depth of cure of resin composites are limited 2 mm. (Flury, Hayoz, Peutzfeldt, Hüsler, & Lussi, 2012) therefore, incremental filling has been recommended. Unfortunately, multiple increments of resin composites are time consuming (Park et al., 2008), difficult to place, easily leave voids within the restoration and gaps between cavity wall of resin composites restoration if not performed carefully (Tiba, Zeller, Estrich, & Hong, 2013).

Resin composites have been developed throughout years, recently, there are new innovation called bulk-fill resin composites. Bulk-fill resin composites perform low polymerization shrinkage therefore microleakage and stress are decreased by exhibiting some elasticity. These materials also demonstrated an improving depth of cure for at least 4 mm., which can be accomplished by their translucency and high conductivity to the light transmission (Lowe, 2010). They have low viscosity, thus allow for easy adaptation to the cavity wall including the gingival margins, existing boxes and easier to dispense with minimal handling (Idriss, Habib, Abduljabbar, & Omar, 2003). Because of their excellent physical properties such as great compressive strength and good wear resistance, bulk-fill resin composites were recommended for posterior teeth restoration (Lazarchik, Hammond, Sikes, Looney, & Rueggeberg, 2007). According to recent study, the mechanical and physical properties of bulk-fill resin composite were evaluated but the studies of surface roughness has not been reported (Furness, Tadros, Looney, & Rueggeberg, 2014; Roggendorf, Kramer, Appelt, Naumann, & Frankenberger, 2011). The bulk-fill flowable resin composite significantly reduces cuspal deflection during light-activation when compared with a incremental placement of conventional resin composite (Moorthy et al., 2012; Roggendorf et al., 2011).

The studies of surface roughness has not been reported. The clinical success of the restorations are related to the appearance and surface smoothness therefore finishing and polishing of resin composites are important procedures. Finishing of resin composites indicate to gross contouring of a restoration to obtain the desired contour. On the other hand polishing indicate to smoothness as well as reduces of the scratches created by the finishing instrument. It has been shown that the longevity of a restoration can be achieved by having a smooth, highly polished surface. Moreover, plaque accumulation can reduced by establishing a smooth restoration, thereby minimizing patient's discomfort from gingival irritation, surface staining, and development of secondary caries (Watanabe et al., 2005). Moreover, different finishing and polishing system could leads to difference in surface roughness of difference resin composite. Thus, the null hypothesis of this study were no significant differences in surface roughness in relation to types of resin composite or polishing system used.

2. Objective

To compare the surface roughness between a bulk-fill (Sonicfill™) and a conventional (Premise™) resin composite after finishing and polishing with two finishing and polishing system (Optidisc, Kerr, USA and Enhance™/Pogo™ system (Dentsply, USA)

3. Material and method

60 pieces of rectangular-shaped resin composite are made from split stainless steel mold (figure 1). The specimens are divided into 2 groups depends on type of resin composite.

Group 1: 30 specimens are fabricated with bulk-fill resin composite. Celluloid strip is placed on bottom of base mold (figure 2) then, place spilt mold above celluloid strip after that place resin composite into spilt mold and the resin composite is covered with a celluloid strip. A glass lab is placed over the celluloid strip to flatten the surface before curing with light activation with Demi Plus™ Kerr for 40 seconds, the light output is 450-470mW/cm2 then the specimen is marked number and type of specimens on the upper right side of spilt mold. Additional 20 seconds of light activation is performed on both sides of specimen after removing the celluloid strip. The specimen is removed from the base mold and excess material is removed by a 320 grit SiC paper (Ergucu & Turkun, 2007).

Group 2: 30 specimens are fabricated with conventional resin composite (Premise™, A3). The same procedures and sequences as follow Group 1.

Each group was divided into 2 subgroups. Subgroup 1: The specimens are sequentially polished with Optidisc™ (Kerr, USA). Medium, fine, and Extra-fine aluminum oxide impregnated disc (Optidisc™) are single used to polish under dry condition for 6 times per 10 seconds. After each polishing step, specimens are thoroughly rinsed with water for 10 seconds to remove debris, air-dried for 5 seconds, and then polished with another disc of lower grit for the same period of time until the final polishing.

Subgroup 2: The specimens are polished with Enhance™/Pogo™ system (Dentsply, USA). An aluminium oxide-impregnated silicon disc (Enhance™) are single used to polish dry condition for 5 times per 10 seconds, rinsed with water for 10 seconds to remove debris, air-dried for 5 seconds, and then polished with disc-shaped of the PoGo™ diamond polishing system for an additional 10 seconds.

In this study, disc-shaped polishers is used to obtain direct contact with the specimens. Laboratory drive units (Perfecta 300, W&H, DentalwerkBÜrmoos GmbH, Austria) with 15,000 rpm by the same operator. The direction is along with the width of split mold (30 mm.)

Surface roughness measurement

The specimens (Spilt mold and Base mold) detect surface roughness by using a profilometer (Talyscan 150, Taylor Hobson, Leicester, UK). Each specimen is measured 5 times at different locations but in same directions. Direction of stylus is perpendicular to polishing direction. Each location is 0.83mm further away from each other and the starting point of the specimen is 1 mm from the mold (As shown in Figure 3). These surface roughness (Ra) is derived from these three readings. Tracing length was 2 mm, stylus speed was 1,500 micrometer/second and cut-off length was 0.08 mm.

Statistic analysis

The data will be collected and analyzed with SPSS 14.0 (SPSS, Inc., Chicago, IL, USA), significance level at 0.05. Mean Ra values will be calculated. Independent t-test will be used to compare the interaction between resin composites and polishing systems. The homogeneity of variances will be checked with Kolmogorov-Smirnov test will be used when the variances were homogenous.

Table 1 Components of bulk-fill resin composite and conventional resin composite.

Materials	Manufacturer	Resin matrix	Type of filler	Filler (% by weight) / (% by volume)
Sonicfill™ Nano-hybrid	Kerr	Bis-GMA, TEGDMA, EBPDMA	SiO_2, glass, oxide	83.5 / N/A
Premise™ Nano-hybrid	Kerr	Bisphenol A diglycidyl ether methacrylate, TEGDMA	Prepolymerized filler (PPF), Barium glass, Silica filler	84 / 70

Table 2 Optidisc™ and Enhance/PoGo™ properties

Types of finishing and polishing systems	Types of particle
Optidisc™(Kerr, USA)	polyester impregnated with aluminum oxide particles
Enhance™ (Dentsply, USA)	aluminum oxide impregnated
PoGo™ (Dentsply, USA)	diamond abrasive impregnated

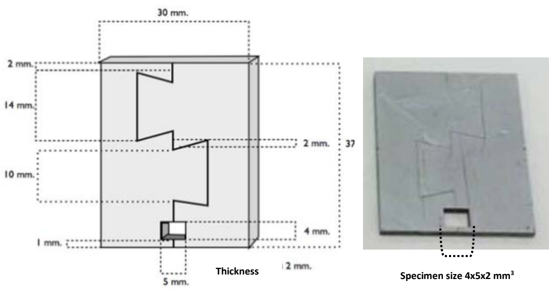

Figure 1 size and shape of spilt mold

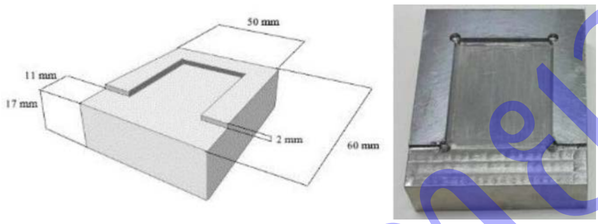

Figure 2 size and shape of base mold

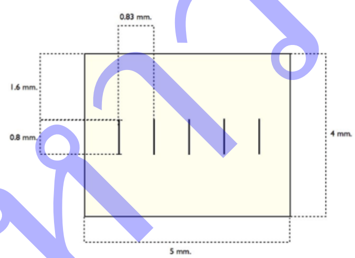

Figure 3 location and direction of stylus process

4. Result

Table 3 Means and standard deviations of surface roughness (Ra, µm) of resin composites for each finishing and polishing systems

Resin composites	Finishing and polishing systems	
	Optidisc™ (Mean ± S.D.)	**Enhance™/Pogo™** (Mean ± S.D.)
Premise™	0.047 ± 0.003^{a}	0.050 ± 0.006^{a}
Sonicfill™	0.076 ± 0.015^{b}	0.099 ± 0.011^{c}
Means value represented with the same small superscript letters within the rows are not statistically different ($p < 0.05$)		

From mean surface roughness values, statistically significant differences were found between two resin composites which polished by Optidisc™ system (Kerr, USA) and two resin composites polished by Enhance™/Pogo™system (Dentsply, USA) ($p < 0.05$). Statistically significant differences were also found in Sonicfill™ which was polished by two finishing and polishing systems ($p < 0.05$). However, there were no statistically significant differences detected in Premise™ which was polished by two finishing and polishing systems ($p > 0.05$).

5. Discussion

Restorative dental materials must fulfill many mechanical and physical properties, one of which is surface smoothness and gloss comparable to human enamel. There are varieties of finishing and polishing instruments described in the literature for resin composite restorations to obtain smooth surface.

The final polished surface of resin composites would be determined by two factors, the composition of composites and the type of polishing system used. The degree of the polymerization of the matrix, the size, composition and volume of filler particles affect the surface finish obtained on composites as the resin matrix and filler particles do not abrade to the same degree (Yap, Yap, Teo, & Ng, 2004). Moreover, factors related to abrasive systems such as flexibility of the material in which the abrasive is impregnated, hardness of the abrasive, geometry, speed and form of application of the instruments used, were also related to final polished surface of resin composites (Scheibe, Almeida, Medeiros, Costa, & Alves, 2009).

The capacity of discs impregnated with aluminum oxide particles to produce smooth surfaces is related to their ability of equally removing particles and organic matrix. The plane movement of the disc contributes to a smoother surface (Ritter, 2001). Disc-shaped polishing systems are proper for contouring and finishing curved surfaces such as labial proximal line angles, lingual marginal ridges, cervical areas, incisal edges, incisal embrasures and labial surfaces. They are also excellent for contouring and finishing of posterior marginal ridge areas. Nevertheless, discs are difficult to produce occlusal anatomic form of posterior teeth.

Enhance™/Pogo™system (Dentsply, USA) polishing system, a rubber-like material, consists of a polymerized resin impregnated with an abrasive. This system has available in different three shapes including cup, point and disc shape. Therefore, Enhance™ /Pogo™ system (Dentsply, USA) can be used for polishing in several surfaces compared to Optidisc™.

On the other hand, Enhance™/Pogo™system (Dentsply, USA) may wear the resin matrix more than Optidisc™ system (Kerr, USA) due to low flexibility, resulting in a higher surface roughness (Yap, Lye, & Sau, 1997).

The present pilot study used polishing machine to prepare the specimens. It demonstrated that the disc did not appropriately contact to the surface of specimens polished with Optidisc™ due to flexibility of the disc. Furthermore, the design of polishing machine can’ t apply pressure when polishing specimen.

On the other hand, Enhance™ /Pogo™ system (Dentsply, USA) is less flexibility than Optidisc™ system (Kerr, USA) so that Enhance™ /Pogo™ system (Dentsply, USA) can be used appropriately to the surface of specimens. The disc can absolutely contact to the surface of specimen. Therefore, the method of using polishing machine was changed to manual finishing and polishing technique by same operator. Moreover, manual finishing and polishing technique was used in many previous studies. (Antonson, Yazici, Kilinc, Antonson, & Hardigan, 2011; Scheibe et al., 2009)

In this study, the surface roughness of resin composites was determined using 2D profilometry. 2D profile tracing results are more commonly reported in dental materials investigations. The surface roughness parameter, Ra, used in the present study is an amplitude parameter characterizing the surface based on vertical deviations of the roughness profile from the mean line. The Ra value is the arithmetic average value of the departure from profile from the center line. Another useful parameter to assess the surface quality of polished resin composites is gloss. This parameter is probably more closely related to a dentist's visual surface evaluation, but not well correlated with the aforementioned surface roughness amplitude parameters such as Ra. (Endo, Finger, Kanehira, Utterodt, & Komatsu, 2010)

According to previous study, the Ra value determined by 2D profilometry that perform visible smooth was less than 1 μm. On the other hand, if 2D surface roughness (Ra) were more than 0.2 μm, it exceeded the clinically acceptable threshold for composite resin restorations. Higher Ra values were accompanied by increased plaque accumulation and higher risk for dental caries and periodontal diseases (Bollen, Lambrechts, & Quirynen, 1997; Chung, 1994)

In the present study, Premise™ gave lower surface roughness than SonicFill™ which polished by two finishing and polishing systems. Premise™ gave statistically significant smoother surface than SonicFill™. Premise™ gave lower surface roughness than SonicFill™ because SonicFill™ has more filler loading than Premise™. However, The specific type of filler in SonicFill™ doesn't officially reported both shape and size of particles.

Furthermore, It was demonstrated that specimens of two resin composites polished with Optidisc™ system (Kerr, USA) provided lower surface roughness value (Ra) compared to Enhance™ / Pogo™ system (Dentsply, USA). Especially in SonicFill™, there were statistically significant differences between two finishing and polishing systems. The particle size of Optidisc™ system from coarse to fine used in this study are 40, 20 and 10 micrometers respectively. While, the particle size of Enhance™ (Dentsply, USA) is 40 micrometers and PoGo™ system (Dentsply, USA) is 20 micrometers. Therefore, Optidisc™ system (Kerr, USA) provided lower surface roughness than Enhance™ / Pogo™ system (Dentsply, USA). According to previous study, the comparison between four-step and two-step finishing and polishing system reported that four-step finishing and polishing system provided better smooth surface than two-step system (da Costa, Goncalves, & Ferracane, 2011).

From previous study, using disc-shaped was recommended for 6 strokes per 10 seconds. (Endo, Finger, Kanehira, Utterodt, & Komatsu, 2010). In pilot study, 5 strokes per 10 seconds were easy to polish. After pilot study, visual inspection found irregular surface of specimens which polished by Optidisc™ system (Kerr, USA). Then Optidisc™ system (Kerr, USA) and Enhance™ /Pogo™ system (Dentsply, USA) polishing 6 stokes in pilot study for compare surface roughness with polishing 5 stokes. The result showed Optidisc™ system (Kerr, USA) that polishing 6 strokes per 10 seconds provided lower surface roughness value (Ra) compared to 5 strokes per 10 seconds. On the other hand, Enhance™ /Pogo™ system (Dentsply, USA) which polished with 6 strokes per 10 seconds provided same surface roughness with 5 strokes per 10 seconds. Therefore, using of 6 strokes per 10 seconds in Optidisc™ system (Kerr, USA) and 5 strokes per 10 seconds in Enhance™ / Pogo™ system (Dentsply, USA) were used in this study (Bashetty & Joshi, 2010).

6. Conclusion

Premise™ showed better surface roughness than SonicFill™ whether finishing and polishing with Optidisc™ system (Kerr, USA) or Enhance™/Pogo™system (Dentsply, USA).

Two different finishing and polishing systems provided different surface roughness for SonicFill™. Optidisc™ system (Kerr, USA) provided better surface roughness compared with Enhance™ / Pogo™ system (Dentsply, USA) for SonicFill™.

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