Original Article

Wear Resistance and Surface Roughness of Injectable Resin Composites after Chewing Simulation

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Abstract

The purpose of this study was to evaluate wear resistance and surface roughness of injectable resin composites after undergoing chewing simulation and compared with those of conventional flowable resin composites and conventional paste resin composites. Ten specimens of each product from three different types: 1) two injectable resin composites (GU, BI), 2) two conventional flowable resin composites (SF, BF) and 3) two conventional paste resin composite (GP,BT), were fabricated in a sample holder and the top surface was polished using silicon carbide papers. The surface topography of the specimens was profiled using a three-dimensional contact profilometer before being subjected to a chewing simulation at 120,000 cycles with a flat enamel antagonist. The surface topography of the specimens was profiled again to determine the wear resistance and surface roughness (Ra). SEM was used to evaluate the surface characteristics of the specimens. After chewing simulation, the conventional flowable resin composites (BF and SF) showed lower wear volume (0.066±0.017 mm^3, 0.084±0.015 mm^3, respectively) than the others. The lowest maximum wear depth was found in the BF group (23.04±4.243 µm). The injectable resin composites (GU and BI) demonstrated a significantly ($P<0.05$) lower mean Ra value (0.147±0.036 µm, 0.168±0.051 µm respectively) than the others. The SEM micrographs of the GU group showed the smoothest surface texture while the BT group demonstrated the largest area of wear as well as the most prominent cracks and plucks of fillers. The baseline surface roughness and surface roughness after chewing simulation have a positive correlation (R=0.367, p=0.004). Wear volume and maximum wear depth have a positive correlation as well (R=0.892, p=<0.001). There was no correlation between wear volume and surface roughness. In conclusion, the injectable resin composites exhibited material dependent wear resistance which might relate to intrinsic factors of the material. In addition, they exhibited lower surface roughness than the flowable resin composites and the conventional paste resin composites.

Keywords: Flowable resin composite, Injectable resin composite, Resin composite, Surface roughness, Wear resistance

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Introduction

Direct restoration in the stress bearing area of the posterior teeth has been the challenge for clinicians in properly choosing the material that possessed both good mechanical properties and ease of handling. This results in the use of an amalgam for more than a century[1] with a substantial amount of tooth structure that needed to be prepared in order to create a proper retention and resistance form. However, with a higher demand of esthetic, the advent of minimally invasive dentistry from a discovery of an adhesive system[2] and concern in the toxicity[3] as well as environmental impact of mercury, amalgam usage has been fading down and replaced by resin composite which possesses a quite similar mechanical properties to the tooth structure[4] and has acceptable clinical performance of up to 33 years.[5]

The conventional flowable (low viscosity) resin composite has been developed from the conventional resin composite and demonstrated better handling and adaptability. However, its physical and mechanical properties were inferior to the conventional type which limited its usage, especially in a stress bearing area.[6] This led to the invention of the injectable resin composite which is also an improved conventional resin composite. The injectable resin composite combines the flowability of the flowable resin composite with the acceptable mechanical properties of the conventional paste resin composite by the incorporation of the lower water sorption resin monomer, improving the silanized coating of filler and reducing the filler size.[7] The injectable resin composites are claimed to be able to be used as direct restoration material for cavity configurations even in a stress bearing area.[8] A two-year clinical study showed a similar performance of the conventional nanohybrid resin composite and the injectable resin composite in Class I and II cavities. The study found that the injectable resin composite showed a slightly higher percentage of restorations that are smooth with low luster (90.7%) compared with the conventional resin composite (83.3%).[9] This might be related to the fact that the wear resistance and flexural strength of the injectable resin composites are similar or better than some of conventional resin composites which are used in a stress bearing area.[10] These improved properties are believed to be achieved by increasing the volume percentage of filler, using the nanosized filler, evenly dispersed filler in the resin matrix and improving the silanization process of the material.[8] Surface roughness is a property of the resin composite which is related to surface and marginal integrity of restoration. As the surface roughness of the resin composite increases, the biofilm formation on the restoration surface increases accordingly which can result in secondary caries or periodontal disease.[11]

However, the information related to wear and surface roughness of the injectable resin composites when occluding with human enamel is limited. Hence, for this *in vitro* study, a chewing simulator was used to evaluate the wear resistance and surface roughness of the novel injectable resin composites and compared to that of the conventional flowable and conventional paste resin composites. The null hypothesis of this study is that the wear resistance and surface roughness of the injectable resin composites are the same as that of the conventional resin composites and the conventional flowable resin composites.

Materials and methods

The research proposal was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Chulalongkorn University (HREC-DCU 2021-065).

<u>Specimen fabrication</u>

Ten specimens of each product from three different types of resin composite (Table 1) were individually fabricated in a round sample holder of a chewing simulator, 10 mm in diameter and 6 mm in height. The material was loaded into the sample holder in three increments. For each increment, 2 mm in height of material was loaded and was light irradiated using an LED light curing unit (Bluephase 2: Ivoclar Vivadent, Lichtenstein) with a light intensity of 1200 mW^2 for 40 seconds. For the final increment, the sample holder was covered with a celluloid strip, a glass slab and a 1 kg metal weight. The weight was applied for ten seconds to ensure the even distribution of material. After the weight was removed, the specimen was light cured for 40 seconds in four overlapping exposures, then the celluloid strip and the glass slab was removed. The specimens were stored dry in the labelled container at 37 °C for 24 hours. The top surface of the specimen was polished with 120, 400, 600 and 2500 grit silicon carbide papers using a polishing machine (NANO 2000, Pace Technologies, USA). The specimen surface was inspected for void and irregularity using a stereomicroscope (SZ61, Olympus, Japan) at 10x magnification to ensure the homogeneity, no void and irregularity of the specimen surface.

Table 1 *Materials used in this study*

Material	Type	Filler components	Percentage of filler (%)	Average size of filler	Shade	Manufacturer	Lot number
G-ænial™ Universal Injectable (GU)	Injectable resin composites	- Silica and barium glass fillers (150 nm) with full coverage silane coating	69% by weight 50% by volume	150 nm	A2	GC, Japan	2201241
Beautifil Injectable X (BI)	Injectable resin composites	-50–60% S-PRG based on fluoroboroaluminosilicate glass and multi-functional glass fillers with total coverage silane treatment -400 nm average particle size	64% by weight 42% by volume	400 nm	A2	Shofu, Japan	072105
Solare Flo (SF)	Conventional flowable resin composites	-Silica fine particles 1-10% -Barium glass 65-75%	79% by weight	-	A2	GC, Japan	2112201
Beautifil Flow F02 (BF)	Conventional flowable resin composites	-40–50% S-PRG filler based on fluoroboroaluminosilicate glass and multi-functional glass fillers	54.5% by weight 34.6% by volume	-	A2	Shofu, Japan	102199
G-ænial™ Posterior (GP)	Conventional paste resin composites	- 17µm pre-polymerized fillers containing 400nm strontium glass and 100nm lanthanoid fluoride -16 µm pre-polymerized fillers containing 16 nm silica - Fluoroaluminosilicate glass (850 nm) - Fume Silica (16 nm.)	77% by weight 65% by volume	-	A2	GC, Japan	2111051
Beautifil II (BT)	Conventional paste resin composites	-60–70% S-PRG based on aluminofluoro-borosilicate glass and 10-20 nm nanofiller, -0.8 microns average particle size -Range of particle size: 0.01-4.0 µm	83.3% by weight 68.6% by volume	800 nm	A2	Shofu, Japan	012266

Silicone index preparation

A square silicone index (29 mm x 29 mm) which has a sample holder at the middle was directly fabricated on the profilometer using additional silicone. After the fabrication, four reference lines were marked on both the index and sample holder to ensure the accurate placement of the sample holder when performing analysis, before and after the chewing simulation.

Enamel antagonist preparation

Thirty human third molars with no carious lesions and restoration were used to fabricate sixty enamel antagonists. The tooth was stored in 0.5% chloramine solution at 25°C immediately after extraction in the container that prevents light exposure. The tooth specimen (2x2x8 mm) was cut at the buccal surface in a bucco-lingual direction using a hard tissue microtome (SP1600, Leica, Germany). The cut specimens were polished using silicon carbide papers from 800 to 1200 grits, and attached into the specimen holder using an acrylic resin.

Baseline surface roughness measurement

Prior to the chewing simulation, the resin composite specimens were put into the silicone index and the surface was scanned using the three-dimensional profilometer (Talyscan 150, Taylor Hobson Limited, England). The starting point was created by moving the stylus tip in the z-axis to the surface of the specimen until the green light indicator was at the middle followed by localizing the x and y axis by moving the base of the profilometer on the area that is going to be measured. These coordinates were saved and used as the reference point for further scanning. The test parameters for the surface roughness measurement was set as 5x5 mm^2 for the surface area, 1000 µm per second for speed, 2 µm for tip radius, 251 parallel tracings, 0.5 µm spacing in x-axis and 20 µm spacing in y-axis, with a cut-off at 0.25 mm and 1.0 mN of force on the stylus.

After surface scanning, the result was analyzed by TalyMap software (Taylor Hobson Limited, UK) which provided both surface profiles and parameters of surface roughness. The arithmetical mean deviation of the assessed profile (Ra) was used to assess the baseline surface roughness of the specimens.

Chewing simulation

The resin specimens was mounted into the testing chamber of the chewing simulator (CS-4.4, SD Mechatronik, Germany), which simulated the occlusal loading equal to 50 N that is equivalent to the normal physiologic bite force of human.[12] The prepared antagonist holder with an enamel specimen was mounted to the antagonist bar. The test parameters was set as a wet environment (100% relative humidity) with a 1.55 Hz frequency at 120,000 cycles, a downward speed of 30 mm/s, an upward speed of 60 mm/s, a horizontal speed of 30 mm/s, a horizontal stroke at 2 mm, a vertical downstroke at 2 mm and a vertical up stroke at 1.5 mm.[13]

Evaluation of wear resistance and surface roughness after chewing simulation

The surface of the specimen was scanned using the three-dimensional profilometer after completion of the chewing simulation. The wear resistance of the specimen was determined by wear volume and maximum wear depth which were calculated from the profiles data using a TalyMap in which the flat area around the wear was used as a reference. The three-dimensional wear tracts were created and also color coded according to the level of depression.

The surface roughness analysis of the area that was affected by wear (1x2 mm) was performed by the arithmetical mean deviation of the assessed profile (Ra) using the TalyMap.

SEM surface analysis

After the chewing simulation, two specimens from each group were randomly chosen, gold sputtered using a modular coating system (Quorum model Q150R, Quorum Tech, UK) and a surface scanned by scanning electron microscope (FEI Quanta 250, Thermo Fisher Scientific, USA) at 50x and 5000x magnifications with operating voltage at 10 kV. The summary of research methodology is demonstrated in Figure 1.

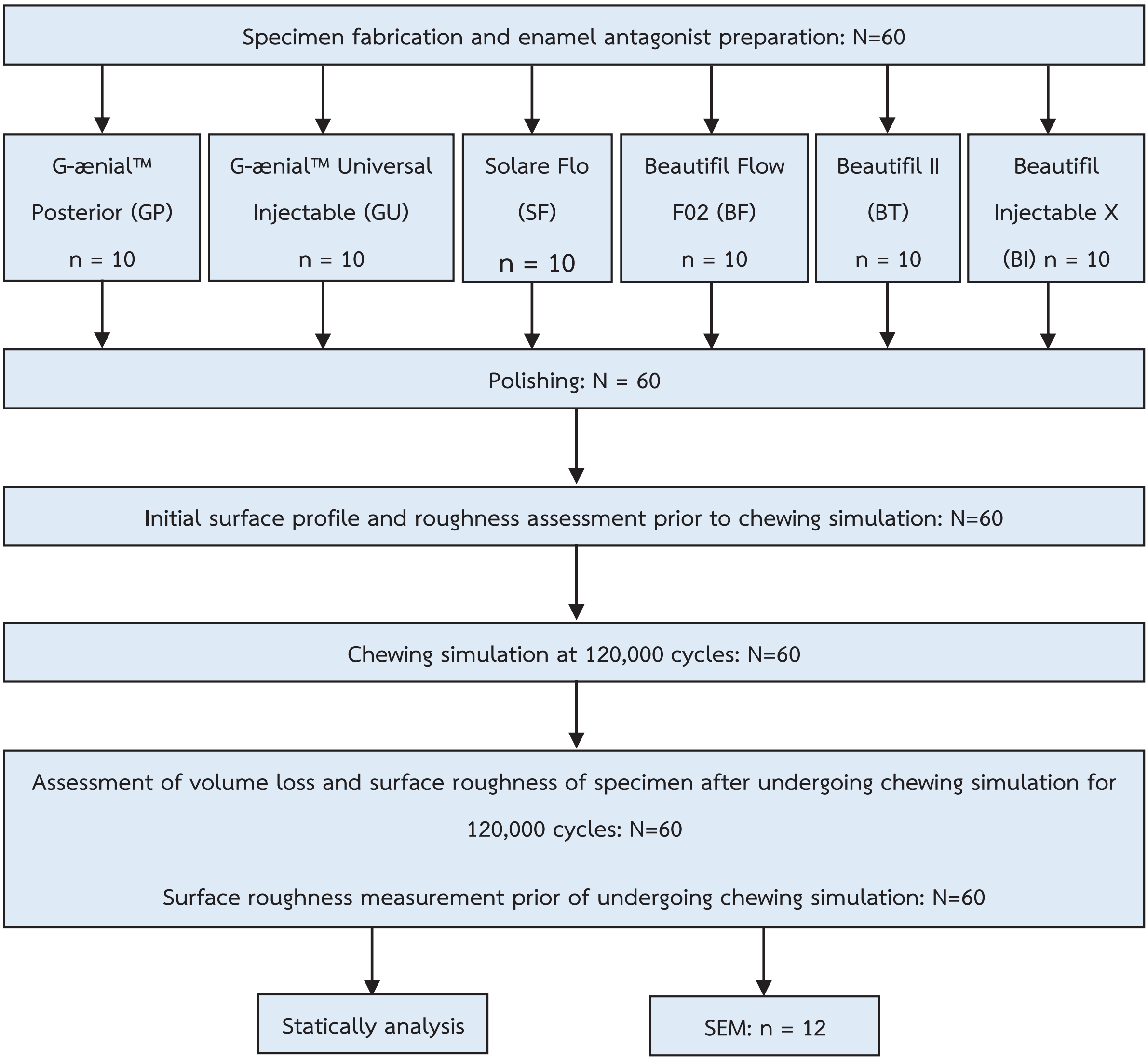

Figure 1 *Flowchart of research methodology*

Statistical analysis

The data were compiled using Microsoft® Excel 2019 (Microsoft, Redmond, WA) and analyzed using the SPSS program for Windows, version 22.0 (SPSS, Chicago, IL). The distribution of the data was determined using the Shapiro Wilk test and the homogeneity of variance was determined by the Levene's test. The correlation between baseline surface roughness, surface roughness after undergoing chewing simulation, wear volume and maximum wear depth was determined by Pearson's correlation. The value of $p<0.05$ is considered to be statistically significant.

Results

Statistical analysis of baseline roughness, roughness after chewing simulation, wear volume and maximum wear depth demonstrated normal data distribution and equal variance ($p>0.05$). Hence, One-way ANOVA and Tukey post-hoc analysis were used for comparable analysis.

Baseline surface roughness of all the experimental groups (Table 2) showed no statistically significant difference ($p=0.629$)

Table 2 Baseline surface roughness

Material	Mean±SD (μm)
G-ænial™ Universal Injectable (GU)	0.087±0.011[A]
Beautifil Injectable (BI)	0.095±0.015[A]
Solare Flo (SF)	0.094±0.019[A]
Beautifil Flowable (BF)	0.098±0.020[A]
G-ænial™ Posterior (GP)	0.095±0.011[A]
Beautifil II (BT)	0.096±0.014[A]

Same superscript in column denotes statistically insignificant difference (p>0.05)

The mean wear volume, the maximum wear depth and the surface roughness after the chewing simulation of all the groups are presented in Table 3. The study found that G-ænial™ Universal Injectable (GU) showed the highest mean wear volume (0.243±0.024 mm^3) followed by G-ænial™ Posterior (GP: 0.183±0.042 mm^3), Beautifil II (BT: 0.177±0.049 mm^3), Beautifil Injectable (BI: 0.127±0.033 mm^3), Solare Flo (SF: 0.084±0.015 mm^3) and Beautifil Flowable (BF: 0.066±0.017 mm3). There was no significant difference between GP and BT groups (*p*=0.998), BI and SF groups (*p*=0.053) and between BF and SF groups (p=0.814)

For maximum wear depth, it was found that the GU group had the highest value (68.945±7.92 μm) followed by GP (48.059±8.692 μm), BT (41.647±5.804 μm), BI (33.243± 4.802 μm), SF (31.801±3.647 μm), and BF group (23.04±4.243 μm). There was no significant difference between the GP and BT groups (*p*=0.199) as well as between the BI and SF groups (p=0.995).

The value of wear resistance was an inverse relationship with maximum wear depth and wear volume values. Hence, the GU group which possessed the highest wear volume and maximum wear depth had the lowest wear resistance. On the contrary, the BF group which possessed the lowest wear volume and maximum wear depth had the highest wear resistance.

For the surface roughness after the chewing simulation, it was found that BT group had the highest value (0.339±0.043 μm) followed by the GP (0.286±0.066 μm), SF (0.261±0.067 μm), BF (0.251±0.085 μm), BI (0.168±0.051 μm) and GU groups (0.147±0.036 μm). There was no significant difference between the BT and GP groups (*p*=0.311), among the BF, SF, GP groups (*p*=0.757), and between the GU and BI groups (*p*=0.960).

Table 3 Wear volume, wear depth and surface roughness after the chewing simulation (Mean±SD)

	Wear volume (mm^3)	Maximum Wear depth (μm)	Surface roughness (μm)
G-ænial™ Universal Injectable (GU)	0.243±0.024[D]	68.945±7.92[D]	0.147±0.036[A]
Beautifil Injectable (BI)	0.127±0.033[B]	33.243±4.802[B]	0.168±0.051[A]
Solare Flo (SF)	0.084±0.015[AB]	31.801±3.647[B]	0.261±0.067[B]
Beautifil Flowable (BF)	0.066±0.017[A]	23.04±4.243[A]	0.251±0.085[B]
G-ænial™ Posterior (GP)	0.183±0.042[C]	48.059±8.692[C]	0.286±0.066[BC]
Beautifil II (BT)	0.177±0.049[C]	41.647±5.804[C]	0.339±0.043[C]

Same superscript in column denotes statistically insignificant difference (p>0.05)

The statistical analysis from Pearson's correlation coefficient (Table 4) found that wear volume and wear depth have strong positive linear relationship (R=0.892, *p*=<0.001). Baseline surface roughness and roughness after the chewing simulation also had a positive linear relationship (R=0.367, *p*=0.004). However, the correlation between the wear volume versus the surface roughness after the chewing simulation and between the wear depth versus the surface roughness after the chewing simulation are not statistically significant (*p*>0.05) which means that they are not correlated.

Table 4 *Correlation between the baseline surface roughness, the surface roughness after undergoing chewing simulation, the wear volume and maximum wear depth*

		Wear Volume	Wear Depth	Baseline Surface Roughness	Surface Roughness after Chewing Simulation
Wear Volume	Pearson Correlation	1	.892	-0.136	-0.144
	P-value		<.001	0.301	0.272
Wear Depth	Pearson Correlation	.892	1	-0.094	-0.225
	P-value	<.001		0.473	0.083
Baseline Surface Roughness	Pearson Correlation	-0.136	-0.094	1	.367
	P-value	0.301	0.473		0.004
Surface Roughness after Chewing Simulation	Pearson Correlation	-0.144	-0.225	.367	1
	P-value	0.272	0.083	0.004	

Figure 2 showed the wear tracts created by the three-dimensional profilometer after the chewing simulation. Each color represented differences in depth. A black area indicated the undermost part of the wear tract followed by blue, green, yellow, red (uppermost part of wear tract) and white areas which indicated the area that was unaffected by wear. The extension of the colored area represented the extension of the wear tract in different depths. The GU group demonstrated an evenly smooth periphery and symmetrical oval shape wear tract while the BI group wear tract shape was more rectangular with smooth and uniform periphery. The SF and BF groups showed a rectangular shape of wear tract with a slightly uneven periphery. The GP and BT groups displayed the uneven periphery and more prominent rectangular shape of wear tracts.

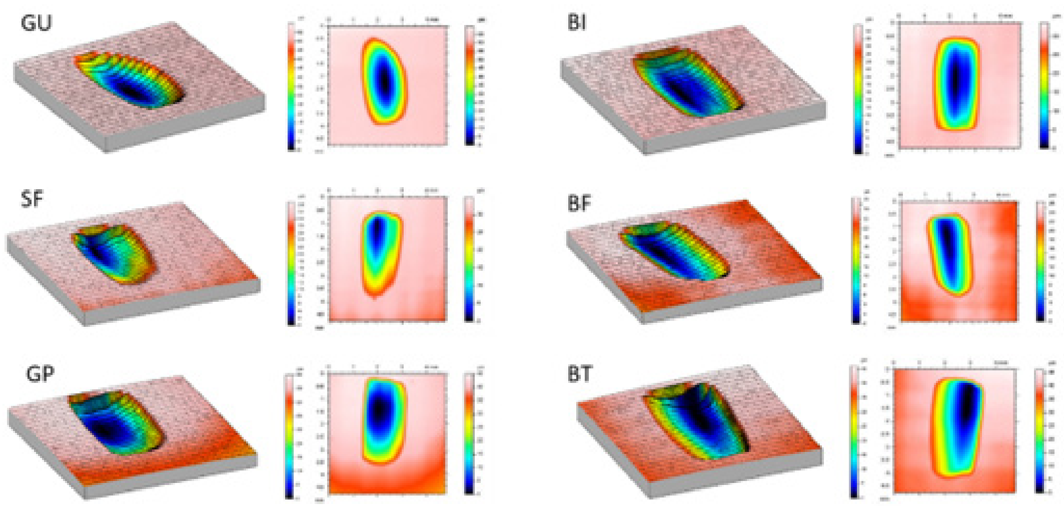

Figure 2 *Wear tracts images after chewing simulation created by the three-dimensional profilometer*

Figure 3 showed the wear tracts from the SEM micrograph at 50X magnification while the GU, BT and GP groups had the large wear area and prominent wear margin. The BT and GP groups showed a slightly rougher surface and margin while the BI, BF and SF groups showed the smooth and shallow wear tracts.

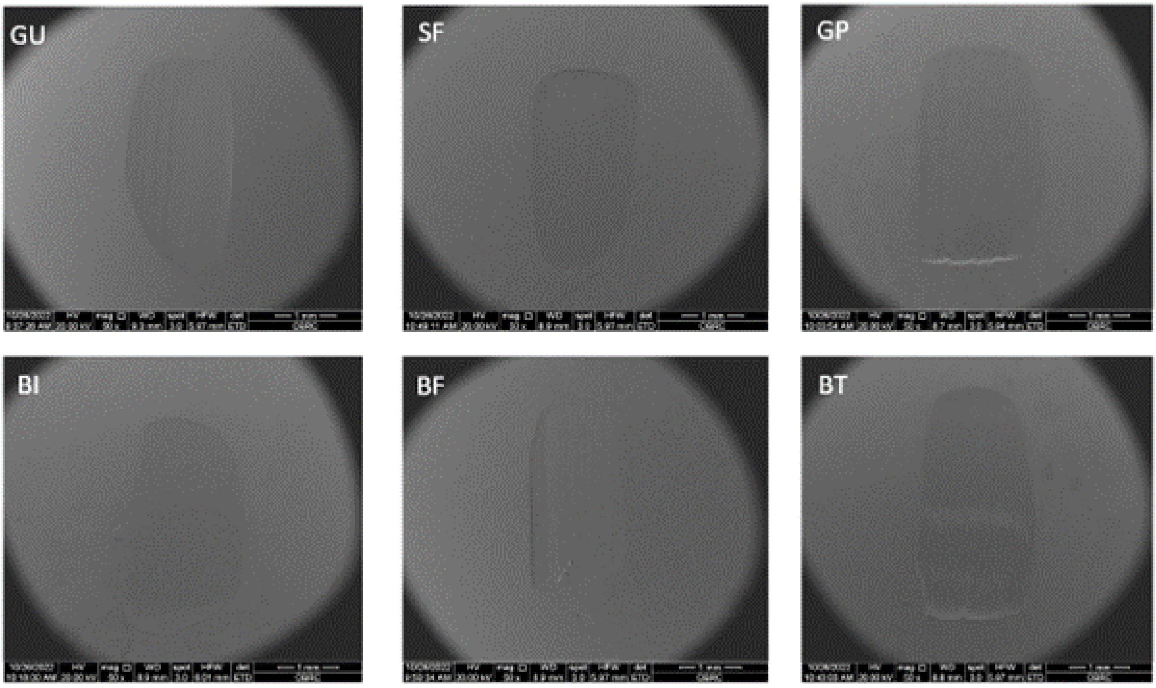

Figure 3 *Wear tract images from SEM at 50X magnification*

Meanwhile, the SEM micrographs of the wear area at 5000X magnification (Figure 4) showed that the BT group had the most prominent large fillers dislodgement and cracks at the surface while the GP group showed a less prominent large fillers dislodgement. The BF, BI and SF groups showed few small fillers dislodgement while the GU group demonstrated the smoothest surface with no filler dislodgement.

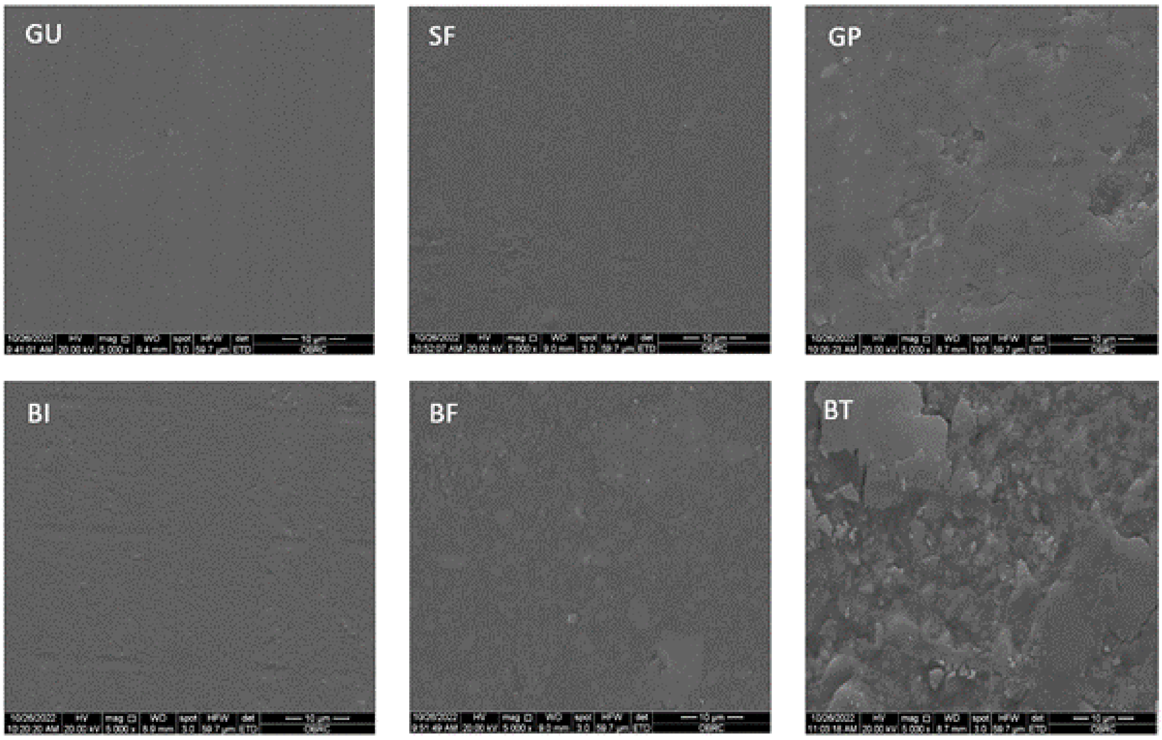

Figure 4 *Wear tract images from SEM at 5000X magnification*

Discussion

Within the limitations of this study, the null hypothesis that the wear resistance and the surface roughness of the injectable resin composite are the same as that of the conventional resin composite and the conventional flowable resin composite is rejected.

In general, wear could be classified as: adhesive wear which results from the welding of two surfaces under load causing the transfer of material from the original surface, abrasive wear which results from surface scraping due to hard surface interact with soft surface (2-bodies wear) or the interfacial interaction of hard particles with the surface (3-bodies wear), fatigue wear which results from repeated force causing subsurface microcrack and corrosive wear which results from the chemical reaction received from the surrounding.[14] In this study, a chewing simulator was used to mimic two-body wear of normal human mastication. The chewing simulator used in this study is a computer-controlled device that can provide dual axis movement (vertical and horizontal), adjustable and reproducible force, lateral movement stylus, continuous supply of water circulation.[15] All these features made this chewing simulator suitable for use in a laboratory wear test that represent clinical oral tooth wear. However, a two-body wear test might not completely mimic the clinical situation of the masticating food compared to the three-body wear test which has a third-body medium to represent food.[16] Hence, this study serves as the preliminary study for further studies relating to wear resistance of resin composites. Human enamel was used as an antagonist that closely resembled the clinical situation. The 120000 cycles of chewing which was selected for use in this study exceeded the running-in phase[17] and is the period of which showed the highest wear rate.[18] Wear resistance is the property of the resin composites which may relate to hardness,[19] flexural strength,[20] the increase of filler in particulate volume,[21] utilization of small filler,[22] high degree of polymerization, high interfacial bond strength, the reduction of hardness difference between filler and resin matrix,[23] filler's hardness[24] and low inter-filler space.[25] This property is directly related to clinical success or failure of the restoration in a stress bearing area which is subjected to numerous forces. Wear started to occur when the applied force exceeds mechanical strength of resin composite which affects the restoration shape and eventually results in the clinical failure of the restoration.[14] The positive correlation between wear volume and wear depth in the previous study suggests that either wear volume or wear depth can be used to evaluate wear resistance.[18] Our study found that the conventional flowable resin composite (Beautifil Flow and Solare Flo) demonstrated lower wear volume than the injectable and conventional resin composites. Wear volume positive correlated to maximum wear depth in which Beautifil Flow showed lowest maximum wear depth despite having the lower filler load. G-ænial™ universal injectable (injectable resin composite) exhibited the highest wear volume and wear depth which were clearly evident in the prominent wear tract in both the three-dimensional rendering from the profilometry and images from SEM. Some previous studies[26,27] found similar findings in which the filler volume and size had no significant relationship with wear resistance. The assumption for this phenomenon is that manufacturers might overestimate filler weight which results in a difference in filler weight when comparing to the filler's weight measurement using thermogravimetry. This method of determining the filler weight includes only the inorganic filler resulting in the lower filler weight for the resin composite that contains pre-polymerized filler which has both organic and inorganic parts.[26,27] Another assumption is that conventional flowable resin composite has higher resilience than the conventional paste resin composite which previous study had found extremely strong positive correlation between wear resistance and resilience of all the resin composite used in the study.[10] In material science, resilience is related to material's ability to return its shape or bounce back to the original form without becoming deformation which can be calculated by measuring the area of the elastic region in the stress-strain plot.[28] However, the injectable resin composite used in this study demonstrated lower wear resistance. This can be implied that this material may exhibit lower resilience compared with conventional flowable resin composite. This can relate to the aim of injectable resin composite that can be used in any cavity classification including the stress bearing area which is susceptible to various direction and magnitude of force and can be resulting in a dislodgment of the restoration if the resilience is too high due to the high elastic strain of the material.[28] Meanwhile, the information relating to resilience of resin composites used in this study is limited. This may require further studies to validate the association between resilience and wear. Another factor that might related to the difference in wear resistance of injectable resin composites is a heterogeneity of filler geometry which previous study found that resin composite with homogeneous irregular shape filler or with mixture of different irregular shape filler demonstrated higher wear resistance which may related to the increase in surface area for adhesion to resin matrix.[22] This could explain the higher wear resistance of Beautifil injectable which has no distinct pattern of filler shape (irregular shape) and filler size at a range of 0.01-4.0 µm compared to G-ænial™ universal injectable which has homogeneous 0.15 µm (150 nm) spherical fillers.

For conventional paste resin composite, large agglomerates such as pre-polymerized filler in G-ænial™ posterior or S-PRG in Beautifil II demonstrated cracks, larger voids from filler pluck, and gap between resin matrix and filler as evident in the SEM micrographs in figure 4 which result in the lower wear resistance of these materials compared to conventional flowable resin composites. This can be related to the inability of these large agglomerates to chemical silane bonded to the resin matrix perfectly.[29] In addition, previous study found that some of the conventional paste resin composites can exhibit the adhesive wear during chewing simulation and can significantly decrease the wear resistance.[30]

Surface roughness is a property of dental material that is related to its composition[31] and to surface polishing which is closely dependent on the operator and polishing protocol.[32] As surface roughness exceeds 0.2 µm, plaque accumulation will occur which results in higher susceptibility to dental caries and periodontal diseases.[33] It can be perceived as rough by patients if roughness exceeds 0.5 µm.[34] The baseline surface roughness of materials used in this study is in the range of 0.076 to 0.13 µm (mean±SD) (Table 2) which is lower than the 0.2 µm threshold. This might relate to the polishing protocol using silicon carbide paper up to 2500 grit. The surface roughness after chewing simulation is in the range of 0.131 to 0.382 µm (mean±SD) (Table 3). The high surface roughness of conventional resin composite (0.220 to 0.382 µm) can be due to the very large filler size which could relate to more protrusion of filler on the surface. Moreover, larger filler tends to leave larger holes when dislodged.[35] This can cause plaque accumulation on the restoration which results in secondary caries and eventually results in the loss of restoration integrity.[33] Only the injectable resin composites can remain the surface roughness close to 0.2 µm threshold (0.131 to 0.219 µm) in which the G-ænial™ universal injectable has the surface roughness below 0.2 µm (0.131 to 0.183).

The low surface roughness of the injectable resin composites (GU and BI) after the chewing simulationmight relate to the improved filler silanization process which was shown in a previous study that the silanized filler results in superior mechanical properties.[36] The high surface roughness of the conventional paste resin composite after undergoing the chewing simulation was found in this study. This was related to the fact that the chewing process caused the surface of the material to wear leading to the exposure and dislodgement of the filler in which the conventional paste resin composite contained a larger filler size (17µm for G-ænial™ Posterior and 4.0 µm for Beautifil II) and has a greater filler percentage (65% by volume for G-ænial™ Posterior and 68.6% by volume for Beautifil II). The surface irregularities were more prominent for this group of material resulting in the high surface roughness observed in this study. The SEM pictures of tested specimens which found the prominent dislodgement of a large filler and the irregularity of the surface topography confirmed this result. These findings were in accordance with a previous study which found similar surface characteristics of Beautifil II showing plucks of large irregular shape particles in size ranging from 10-50 μm after water immersion.[37] Moreover, Beautifil II has a higher degree of water absorption in order to be able to release fluoride or other ions to the environment[38] resulting in more porosity and ultimately which leads to a higher surface roughness. For G-ænial™ Posterior after chewing simulation, a previous SEM study found the exposure of filler. However, the surface roughness is higher than our study (1.54±0.47 μm VS 0.18 ±0.04 μm)[26] This may relate to the use of steatite as the antagonist, a difference in polishing protocol of the tested specimen and the higher baseline surface roughness. The positive correlation (directly proportional) of the baseline surface roughness and the surface roughness after chewing simulation (R=0.367, p=0.004) confirmed this speculation.

The injectable resin composites are marketed as the improved version of the conventional flowable resin composite which can be used in a stress bearing area like conventional paste resin composite but with flowability thus improving the versatility and accommodate the clinical usage.[7] Previous clinical studies showed promising results of the previous generation of injectable resin composite when used in stress-bearing area.[9,39] The injectable resin composites seem to demonstrate the wear resistance which is material dependent despite the low surface roughness which may require further experimental study. The use of this material in a stress bearing area might be feasible if the selected material demonstrates wear depth similar to enamel which is about 35 to 38 microns per year.[40] This can ensure the integrity and good longevity of the restoration.

Conclusion

After the chewing simulation, the injectable resin composites exhibit material dependent wear resistance. However, the surface roughness of the injectable resin composites is lower than the conventional flowable resin composites and the conventional paste resin composites.

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