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Original Research Article

The effect of brushing on surface finish of two different indirect composite resin systems finished by polishing and glazing - An invitro study

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Abstract

Background: Composite restorations are being used in dentistry due to their good optical and mechanical properties, however, they exhibit poor wear resistance property when used as posterior restorative material. To overcome this drawback indirect composites were introduced. Daily tooth brushing causes abrasion of poorly finished surfaces of indirect composite. The aim of the study was to assess the effect of brushing on surface roughness and surface finish of two different indirect composite resin systems finished by polishing and glazing.

Materials and Methods: The Specimens were divided into group A and group B with a sample size of 15 in each group. Group A specimens were fabricated using Crea.lign indirect composite resin system and group B specimens were fabricated using GC Gradia indirect composite resin system. Baseline surface roughness measurements (Ra) were noted using contact profilometer before brushing simulation. These samples were subjected to brushing simulation and final surface roughness measurements were noted and compared with the baseline surface roughness measurements. The obtained data was tabulated for statistical analysis.

Results: Wilcoxon signed rank test was used to compare the mean surface roughness values of group A and group B before and after brushing. The test revealed that there was a statistical difference ($P<0.002$) in both the groups before and after brushing simulation. Mann Whitney U test was used to compare the mean surface roughness values of group A (polished samples) and group B (glazed samples) before and after brushing. The test revealed that there was a significant difference before ($P<0.001$) and after brushing simulation ($P<0.001$).

Conclusion: Group A specimens produced greater mean surface roughness values before and after brushing simulation when compared to group B specimens whereas the surface finish produced by group B specimens (glazed group) was better than surface finish produced by group A specimens (polished group).

Keywords: Composites, Polishing, Glazing.

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1. Introduction

Composite resins today occupy a paramount position among restorative materials as they offer exemplary aesthetics and acceptable longevity, with a much lower cost than ceramic restorations for the treatment of both anterior and posterior teeth.[1] Composite restorative materials represent one of the many successes of modern biomaterials research, since they replace biological tissue in both appearance and function. During the past 60 years, the use of composite resin for direct restorations in anterior and posterior teeth has increased significantly, largely due to the aesthetic demands of patients.[2] Dental composite formulations have been evolving since 1962 with the introduction of Bis-GMA to dentistry.[3,4] Composites were introduced into the field of dentistry to overcome the limitations of acrylic resins which replaced silicate cement. Composites can be divided into direct and indirect resin composites.[3,4] Direct composites are directly placed into the oral cavity and cured whereas indirect composites are processed extra-orally in a processing unit that is capable of delivering higher intensities and levels of energy than handheld lights.

Direct resin composites were earlier introduced for use as restorative materials for anterior teeth. Later, with advances in technology, the restoration of posterior teeth with direct composites had begun. Though there are various causes for failure of clinical restorations made of direct composites,

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the major cause with the earlier posterior direct composites was poor wear resistance. To address this clinical challenge of direct composites, manufacturers created materials and techniques for the indirect composite restorations. This has lead to the decrease in the amount of intraoral polymerization shrinkage, better proximal restoration contours, improved command over marginal adaptation, improved physical properties of the restorative material, improved polishability, reduced water solubility, and increased hardness.[5] The disadvantages most frequently associated with the indirect technique are that it requires two appointments and it requires more time to place than the direct technique.

An ideal composite restorative material should have wear properties similar to those of tooth tissues.[3] Based on the mechanism of action, wear can be divided into abrasive, adhesive, fatigue, or corrosive.[6] Tooth brush abrasion is one of the most common types of wear that not only affects teeth but also dental restorations.[7-12] In clinical conditions, the abrasive wear caused by tooth brushing affects all exposed surfaces of a composite resin restoration, while abrasion caused by occlusal forces is limited to contact surfaces.

The prime requirement of restorative material in general is the ability to take and retain a smooth surface finish. Glazing results in more aesthetic appearance and better gloss whereas polishing can be easily done by usage of different polishing kits available in the market. Therefore, it is necessary to find out if the manually polished indirect composite specimens produce the same surface finish that will be produced by glazed indirect composite specimens. The purpose of the present study was to evaluate and compare the effect of brushing on the surface finishes of two different next generation indirect composite resin systems finished by polishing and glazing.

2. Materials and Methods

2.1. Mould preparation for indirect composite specimens

A 2mm stainless steel sheet with wire-cut holes of dimensions 2mm (thickness) x 5mm (width) x 10mm (length) was used to fabricate 15 specimens of each indirect composite material.

2.2. Making of group A and group B specimen

Crea.lign and GC Gardia composite specimens were fabricated in the stainless steel mould placed on a clean glass slab. Crea.lign was cured with a light-polymerizing unit (bre.Lux Power Unit; bredent GmbH & Co KG) for 180 seconds at a wavelength between 370 nm and 500 nm whereas GC Gradia composite specimens were initially cured in a Gradia Step Light for 10 seconds. This was followed by application of air barrier liquid on the surface of specimen and final curing with Gradia Labolite Duo for 5 minutes.

The two different next generation indirect composite resin systems used were Creal.lign which is a nanofill composite and GC Gradia which a nano hybrid composite. The composition of these two resins mainly differ in filler particle size, type, distribution and loading. The reason for choosing two different indirect composite resin materials is to verify the claims of the manufacturer and to evaluate if both the composites produce similar surface finish after brushing simulation.

2.3. Finishing and polishing of group A specimen

Each surface of the specimen was finished with coarse grit (P200) silicon carbide abrasive paper for 10 seconds followed by fine grit (1000P) silicon carbide abrasive paper for 10 seconds.

Silicone rubber polishing wheel was used to smoothen and pre-polish the surface of the specimen for 10 seconds at a speed of 3000 rpm. Abraso fix round brush was used for 10 seconds at a speed of 3000 rpm to ensure pre-polishing. Polishing was done with Round black goat hair brush and Acrypol polishing paste for 10 seconds at a speed of 3000 rpm followed by round white goat hair brush for 10 sec at a speed of 3000 rpm. Lenin buff and Abraso Starglanz polishing paste was used for high lustre polishing. Polishing was done only on one surface of the specimen to differentiate polished surface from non-polished surfaces of the specimen. Each Specimen was cleaned with soap water and brush for 10 seconds. Further they were steam cleaned for 10seconds and then air dried. The specimens were again dry polished with cotton buff for 10 seconds at a speed of 3000 rpm. Care was taken that the finishing and polishing procedure was done in a unidirectional manner.

2.4. Finishing and polishing of group B specimen

After curing of the specimens they were retrieved from the mould and contoured to shape with tungsten carbide bur for 10 seconds at a speed of 3000 rpm and finished with Silicon carbide abrasive papers ranging from coarse to fine grit - 400 grit, 600 grit, 800 grit, 1000 grit. Care was taken that the finishing procedure was done in an unidirectional manner. The specimens were then subjected to glazing with few drops of Optiglaze Color clear HV solution. It was applied only on one surface of the specimen with a brush to differentiate glazed surface from nonglazed surface. Light curing was done with Labolight Duo for 3 mins.

2.5. Testing of initial and final surface roughness of group A and group B specimens

Three Initial and final surface roughness measurements were made before and after tooth abrasion test in the centre of each specimen and their average was noted as mean surface roughness (Ra) using a contact profilometer (MITUTOYO SJ-310). The contact profilometer (MITUTOYO SJ-310) has a cut-off length of 0.8mm and measuring force of 0.75µm and tip angle of 60 degree that moved along the length in the centre of the specimen for a distance of 8mm. The baseline measurement of mean surface roughness of each specimen was noted. The final surface roughness measurements were recorded and compared with the baseline data to evaluate the surface roughness and surface finish of indirect composite resin systems.

2.6. Standardisation of brushing simulation

Cylindrical putty mould and die stone were used to form a template that held the specimens in the brushing simulator. Specimens were placed on the die stone templates when setting process was taking place and after complete setting of the die stone it was retrieved from the putty mould. They were placed in the brushing simulator that consisted of 8 brushing compartments. Sensodyne toothbrush heads with soft grade bristles was used with slurry water made with Colgate anticaries tooth paste with relative dentin abrasion value of 70 and distilled water in a ratio of 1:1. Brushing load of 250-300gms was applied on the specimens at a speed of 30mm/sec in circular motion covering the specimens uniformly. 5000 cycles were required to simulate tooth brushing for 6 months at a rate of 30 cycles/day. After toothbrushing the specimens were removed from die stone template, cleaned with distilled water in an ultrasonic bath and then air dried.

2.7. Statistical analysis

Wilcoxon signed rank test was used to compare the mean surface roughness values of group A and group B before and after the brushing. The test revealed that there was a statistically significant difference (P=0.002) in both the groups before and after brushing simulation. Mann Whitney U test was used to compare the mean surface roughness values of group A (polished samples) and group B (glazed samples) before and after brushing.

3. Results

The obtained data of group A and group B specimens before and after brushing simulation was tabulated as shown (**Table 1**-**Table 5**).

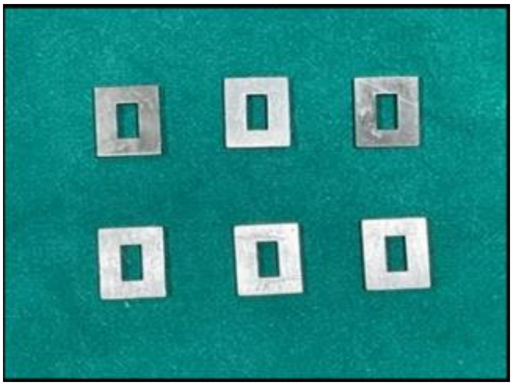

Figure 1: Custom made stainless steel mould with 2mm X 5mm X 10mm dimensions

Figure 2: Materials for fabrication of crea.lign indirect composite resin specimens

Figure 3: Materials for fabrication of GC Gradia indirect composite resin specimens

Figure 4: Toothbrush Simulator ZM 3.8 (SD Mechatronik)

Figure 5: Contact profilometer (Mitutoyo SJ-310)

Table 1: Shows comparison of mean surface roughness (Ra) and standard deviation (SD) of group A samples before and after brushing simulation.

Group	Before brushing		After brushing		P-value
	Mean(µm)	SD	Mean(µm)	SD	
Group A	1.05	0.36	1.95	1.01	0.002(S)

Table 2: Shows comparison of mean surface roughness (Ra) and standard deviation (SD) of group B samples before and after brushing simulation.

Group	Before brushing		After brushing		P-value
	Mean(µm)	SD	Mean(µm)	SD	
Group B	0.61	0.37	0.89	0.39	0.002(S)

Table 3: Shows the mean surface roughness (Ra) and standard deviation (SD) of group A and group B samples before brushing.

Group	Before brushing	
	Mean(µm)	SD
Group A	1.05	0.36
Group B	0.61	0.37
P-value	0.001(S)	

Table 4: Shows the mean surface roughness (Ra) and standard deviation (SD) of group A and group B samples after brushing.

Group	After brushing	
	Mean(µm)	SD
Group A	1.95	1.01
Group B	0.89	0.39
P-value	0.001(S)	

Table 5: Shows the mean of mean difference in surface roughness (Ra) and standard deviation (SD) after and before brushing between group A and group B samples.

Group	Mean difference	SD	P-value
Group A	0.89	0.89	0.03(S)
Group B	0.29	0.39	

Table 1 The test showed that there was a statistically significant difference (P<0.002). The mean surface roughness of group A after brushing simulation (1.95µm) was significantly higher than the mean surface roughness before brushing simulation (1.05µm).

Table 2 The test identified a statistically significant difference (P<0.002). The mean surface roughness of group B after brushing simulation (0.89µm) was significantly more than the mean surface roughness before brushing simulation (0.61µm).

Table 3 The mean surface roughness of group A before brushing simulation (1.05µm) was significantly greater than the mean surface roughness of group B before brushing simulation (0.61µm) and the difference obtained was statistically significant (P<0.001)

Table 4 The mean surface roughness of group A after brushing stimulation (1.95µm) was significantly higher than the mean surface roughness of group B before brushing simulation(0.89µm) and the difference was statistically significant (P<0.001).

Table 5 The test presented a staitsically significant difference (P <0.03). The mean of mean difference in surface roughness of group A (0.89µm) was significantly more than the mean of mean difference in surface roughness of group B (0.29µm) respectively.

4. Discussion

The main objective of the study was to compare and evaluate the effect of brushing on the surface finishes of two different next generation indirect composite resin systems and also to assess the surface roughness of these two different next generation indirect composite resin systems finished by polishing and glazing.

The mean surface roughness and standard deviation of group A after brushing simulation was found to be significantly higher than mean surface roughness and standard deviation produced before brushing simulation. The mean surface roughness and standard deviation of group B after brushing simulation was found to be significantly greater than mean surface roughness and standard deviation produced before brushing simulation which is in accordance with the studies done by Gracia FC et al (2004),[11] Teixeria EC et al (2005),[16] Moraes RR et al (2008).[17]

The mean surface roughness and standard deviation of group A (polished samples) before brushing simulation was significantly greater than the mean surface roughness of group B (glazed samples) before brushing simulation. The mean surface roughness of group A (polished samples) after brushing simulation was significantly greater than the mean surface roughness of group B (glazed samples) after brushing simulation which is in conformity with the study conducted by Tekce N et al (2018).[10] According to the study conducted by Stoddard JW, Johnson GH (1991)[18] the surface produced by using mylar strip and polishing with Moore's disk produced similar smoothness as that of glaze material which is contradicting with the current study.

In the present study, the probable reason for increase in the mean surface roughness after brushing simulation is due to abrasion of the soft resin matrix leading to exposure of the filler particles. Various other factors also play an crucial role for increase in surface roughness after brushing simulation. They are the type of resin matrix, filler material, filler particle shape, size, filler loading, the strength of bond between filler particles and resin matrix, degree of conversion, polishing methods and materials, relative dentin abrasivity (RDA) of the toothpaste. Irregularly shaped filler particles tend to produce high surface roughness values when compared to spherical shaped filler particles after long- term tooth brushing.[13-18]

The greater surface roughness values produced by Crea.lign specimens when compared to GC Gradia specimens before and after brushing is due to various factors. The filler particle size of Crea.lign indirect composites is comparatively less than that of GC Gradia indirect composite, but the probable reason for increase in surface roughness may be due to filler particle type, shape, loading and particle distribution. Crea.lign indirect composite has an urethane dimethacrylate, 1,4, butanediol dimethacrylate matrix with 50% opalescent ceramic fillers with no ground glass with filler particle size of 40nm and filler loading of 60% by weight whereas GC Gradia indirect composite has 1-5% Bisphenol A – glycidyl dimethacrylate, 5-10% triethylene glycol dimethacrylate, 1-5% urethane dimethacrylate matrix with different type of filler particles like prepolymerized resin filler, ceramic fillers with particle size of 300nm and inorganic filler loading of 71% by weight and prepolymerised filler loading of 6% by weight. The Crea.lign indirect composite is a nanofilled composite with homogeneous, discretely arranged spherical nanomeric fillers and nanoclusters when compared to GC Gradia indirect composite which is a nanohybrid composite with both spherical and irregularly shaped fillers and with a blend of two or more size ranges of filler particles, one or more of which is a nanoparticle range. Another possible reason for lesser surface roughness and better surface finish produced in GC Gradia specimens might be due to glazing of the specimens before subjecting them to brushing simulation.

5. Limitations

Limitations of the study were that while fabrication of specimen voids were incorporated during incremental addition of composite into the mould. Also, during retrieval of indirect composite specimen from the mould, there was chip-off of the composite that led to difficulty in producing a smooth surface texture. Many steps in the fabrication of the specimens like finishing, polishing and application of glaze were done manually. The results with regard to the surface texture, however can be different from one specimen to the other. These factors alone or in combination may contribute to the variability of the results and to the inconsistencies. Furthermore, lack of methods to analyse natural wear during mastication and habits like night grinding and clenching of teeth would add up to the limitations. Another limitation of the study is the absence of simulation of continuous washing action of the saliva similar to clinical situation.

These reports illustrate that the type of restorative materials and the surface conditions obviously have an impact on the abrasion caused by tooth brushing of the restorative materials.

6. Conclusion

The mean surface roughness of both Group A and Group B samples before brushing simulation was found to be less than the mean surface roughness value after brushing simulation. Furthermore, the mean surface roughness produced by group B samples (glazed group) was less than the group A samples (polished group) before and after brushing simulation. The surface finish produced by group B samples was better than the surface finish produced by group A samples before and after brushing simulation. The Indirect composite restoration with smooth surface finish showed less abrasion due to brushing simulation when compared to indirect composite restorations with irregular surface finish.

7. Source of Funding

None.

8. Conflict of Interest

None.

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