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Original Article

The Influence of Two Surface Treatment Techniques with Different Adhesive Systems on the Shear Bond Strength of Composite Resin Repair

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ABSTRACT:

Purpose: To evaluate the influence of different adhesive application protocols with two surface treatment methods on the shear bond strength of aged composite repair.
Material and Methods: 90 cylindrical-shaped samples (8mm × 4mm) were prepared from Estelite Sigma Quick composite resin, After the thermocycling, the samples were divided into two main groups according to the surface treatment and then each group was further subdivided to five groups according to bonding procedures. For the repair, the same brand of old composite with the same shade was used. Then, the shear bond strength test was completed by the Universal Testing Machine. For statistical analysis, the IBM SPSS statistics program was used (SPSS IBM, Turkey).
Results: There was a statistical significant difference between the shear bond strength values in Mpa among all sub-groups.
Conclusion: The shear bond strength obtained by the mechanical surface grinding with diamond bur is statistically significant higher than that obtained with air abrasion surface treatment. The combination of universal adhesive system or two-step self-etch adhesive system and grinding with diamond bur for repair procedures provide the highest values of SBS.

Keywords: composite repair, surface treatment, bonding procedures. shear bond strength.

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The introduction of resin-based composite materials to the field of restorative dentistry was one of the most important contributions in the last century [1].Composite resin material has become the first choice for direct restorations in both anterior and posterior teeth. Systemic reviews have concluded that, the dental composite restorations might have adequate clinical performance, with annual failure rates (AFRs) change from 1% to 4%. Nevertheless, replacement of failed restorations is still very common in general and private clinic, taking significant part of clinical time with high financial costs for health systems [2].The main causes of restoration failure are Secondary Caries which mainly occurred at the margin of the exciting restoration. the second cause is the fracture which may be bulk fracture or just degraded or ditched margin especially with composite veneer. also esthetic defect, mainly in the form of marginal or surface staining, or it might be a mismatch of color during steps of treatment [3,4].A failed restoration although with little defects are regularly treated by most clinicians with replacement of the whole restoration [5]. Even though the replacement of restorations may provide superior clinical results and higher aesthetics, it may also cause additional destruction of tooth structure and pulpal injury while being time-consuming and costly. Therefore, repair of composite restorations might be a more suitable choice, since it saves time, cost and the remaining tooth structure when compared to complete replacement [6]. In the repair of old dental composite, it should be well-known that alterations that take place in composite resins over time as a result of aging might decline the reactivity of old composite and complicate the repair procedure [7], so the purpose of an artificial aging process is to duplicate these variations which occurred during the clinical service [8].Several techniques have been used in different studies for aging procedure such as thermocycling, boiling and storage in different solutions (citric acid, sodium chloride or distilled water) [9]. The aim of thermocycling procedure is to initiate thermal strains at the bonding interface with thermal variations in water baths in a range of 5-55ºC. The recurrence of thermal changes in this process weakens the bond between the filler and organic matrix of composite material [10].Achieving an appropriate bond between the aged and fresh composite resin is challengeable due to the absence of oxygen inhibited layer and the reduction in the number of accessible C=C double bond which is very important to react with new composite [11].Rodrigues et al. reported that, the repair procedure was accomplished with three mechanisms; Micromechanical interaction through surface irregularities, Chemical union between two resin materials and, Chemical linkage between the restorative material. The surface treatment procedure of aged composite resin has two main functions which are Elimination of most superficial layer. and Formation of surface micro porosities [12]. There are a number of mechanical and / or chemical surface pretreatment methods to roughen the composite surface such as Roughening with diamond bur, carbide bur, silicon carbide paper or green carborundum stone, Air abrasion with aluminum oxide particles (50µm in size), or with silica coating particles, etching with 37% phosphoric acid gel, or etching with 8-9% hydrofluoric acid [13]. Although there are several studies tested different surface treatment methods, none of these treatments can be suggested as a universal technique for successful repair. Melo et al. reported similar bond strength for composite resin repair following a surface preparation with diamond bur, phosphoric acid, saline, adhesive and air abrasion when compared to the control group [14].Using an intermediate adhesive agent in the repair processes has also significant effect on the durability of old restorations repairs. Bond strength of the repaired restoration is greatly enhanced after the adhesive agent are applied following surface treatments [15].The favorable effect of adhesive agents on the repair bond strength is essentially correlated to The improvement in a chemical bond to the matrix of old resin materials and to the uncovered fillers [16]. Although the Enhancement in the micromechanical retention by the penetration into the micro-roughness formed by the surface treatment methods [17]. Some researchers investigated the influence of numerous adhesive systems on the repair bond strength of aged composite resin. Lucena et al. explained that, the low-viscosity filled bonding agents have been established to have a high wetting ability of composite resin surface and infiltrate within the organic phase [18,19].

MATERIALS AND METHODS

90 cylindrical shaped specimens (8mm × 4mm) were prepared from Estelite Sigma Quick composite resin with A2 shade using a transparent

mold. Then to provide a constant smear layer, the uppermost surfaces of the specimens were grinded by (2500 grit silicon carbide paper) using a polishing device. Then the specimens were kept in distilled water for another 24 hours, after that the specimens were exposed to 10.000 thermal cycles with thermocycling machine. Subsequently the specimens were divided into two main groups according to the surface treatment; group A with diamond bur grinding and group B with air abrasion treatment. After the surface treatment, each of main groups were further subdivided into five sub-groups according to bonding procedure; first Sub-group with Single Adper Bond 2 (two-step total-etch adhesive) (3M ESPE St Paul, USA) , second sub-group with Clearfil SE Bond (two-step self-etch adhesive) (Clearfil SE Kuraray Tokyo, Japan) with selective etching technique, third subgroup with Two-step self-etch adhesive system (without etching), fourth subgroup with Selective etching with universal adhesive system (G-Perimo Bond,GC Cooperation, Tokyo Japan) and fifth subgroup with Universal adhesive system.After the adhesive applications, the upper part of the mold (2mm×4mm) was firmly fixed over the aged composite discs. For the repair, the same brand of old composite was used.For shear bond strength test (SBS) the specimens were stored in 37C^{o} water path for 24 hours, then the specimens were embedded into the chemically cured acrylic resin each within a metal blocks. Subsequently, the shear bond strength test was completed by the Universal Testing Machine. After completing the test, the specimen's surfaces were analyzed to determine the type of adhesive failure using a surgical microscope (73446 Oberkochen, Carl Zess Surgical / Germany) with 12× magnification.

Data analysis:

For statistical analysis the IBM SPSS statistics program was used (SPSS IBM, Turkey). Two-way ANOVA test was used to compare common effect of the main group and sub-groups on shear bond strength in the comparison of the quantitative data. The One-way ANOVA test and the (Tukey HDS test) Tamhane's T2 test were utilized to detect the groups that caused the difference. Student test was used to compare the two groups of parameters. Statistical significance level was established at $p < 0.05$.

RESULTS

There was statistical significant difference between the shear bond strength values in Mpa among all sub-groups (p: 0.000, p<0.05) (table 1).

The shear bond strength values of diamond bur surface grinding plus universal adhesive applied group was found to be statistically higher than the other groups (except the diamond bur grinding plus two-step self-etch adhesive applied group).

DISCUSSION

Different bond strength tests were used to assess the repair durability of aged composite resin. The shear test is the most frequently utilized method for evaluation of repair bond strength [20].

During repair procedures of old composite there are number of factors that effected the result of bond strength assessment and the most important factors are Surface pretreatment of old composite and the Use of intermediate bonding agent. Pervious researchers reported that, the most essential factor contributing to repair bond strength is the mechanical interlocking [21]. In studies, using SEM (scanning electron microscope) for newly abraded composite surfaces prior to the bonding process, the assessement revealed an irregular surface with pits, grooves, porosities, and exposed filler particles that enhance the micromechanical retention [22].There are various methods for the surface treatment, among these methods the most common tested in pervious researches are the diamond bur surface grinding and air abrasion with aluminum oxide. Roughening the surface with diamond bur is a significant way for promoting macro- and micro-retention in the substrate. Micro-retention provided by the bur is almost certainly a common cause of bonding to the underlying composite surface [23]. Another most common surface treatment used for surface conditioning is the sandblasting (air abrasion) with aluminum oxide particles or with silica coated particles. Air abrasion is capable to create surface irregularities on the aged composite by mechanical shocking of alumina particles, irregularly eliminating parts of the polymer matrix and filler particles [24].When comparing the roughness configuration of air abrasion and surface grinding with diamond bur treatment; the grinding with diamond bur provide macro-and micro- retention features, while air abrasion initiate just micro-retention features [25]. The result of our study concluded that, the SBS of the diamond bur grinding group (14,38±2,34) was found to be significantly higher than that of air abrasion group (12,29±1,84) with (p: 0.00, p<0.05) regardless the effect of different adhesive protocols.

The results of our study was in consistent with result of study by Tabatabaei et al., who concluded that, the grinding with diamond bur is most operative surface treatment technique for repair procedure of composite resins [26]. And also Bonstein et al. evaluated different repair's protocol for aged composite restoration using five surface preparation protocols and concluded that, the surface preparation with bur and air abrasion created the highest bond strength [27].In contrast, Cavalcanti et al. established that, the surface pretreatment of composite resins with air abrasion technique provide a higher repair bond strength values in comparison to diamond burs [28].

Table 1: Evaluation of shear bond strength values in Mpa between all sub-groups

All Groups	Shear Bond Strength Mpa Mean± Sd
Diamond Bur Surface Grinding + Adper Single Bond 2	10,28±0,64
Diamond Bur Surface Grinding + Se Clearfill Bond With Selective Etch	14,28±0,71
Diamond Bur Surface Grinding + Se Clearfill Bond	15,91±1,15
Diamond Bur Surface Grinding + G-Perimo Bond With Selective Etch	14,94±0,52
Diamond Bur Surface Grinding + G-Perimo Bond	16,5±0,79
Air Abrasion Treatment +Adper Single Bond 2	12,99±0,61
Air Abrasion Treatment + Se Clearfill Bond With Selective Etch	14,74±0,49
Air Abrasion Treatment + Se Clearfill Bond	9,57±0,99
Air Abrasion Treatment + G-Perimo Bond With Selective Etch	11,86±0,82
Air Abrasion Treatment + G-Perimo Bond	12,31±0,7
P	0.000

So in our study we selected the diamond bur grinding and air abrasion as the surface treatment methods to compare their effect on SBS.The diamond bur grinding provides both micro- and macro retentive features which enhance the bonding between the old and new materials and this might be contributed to a high SBS values for diamond bur grinding group.Some investigators have confirmed a diminishing in repair bond strength after air abrasion and they have mostly attributed this decrease to the exposure of the filler particles after abrasion, and therefore diminish the opportunity for primary bonding to the resin [29].There is a large number of studies about the effect of surface treatment on repair bond strength of aged composite and there is difference in findings which might be correlated to the type of composite used. they concluded that compositions

of resin composites might influence the effectiveness of different mechanical surface treatments, and the degree of surface roughness produced [30].Repair bond strength of composite resins is greatly increased when the bonding agents are applied subsequently after surface treatment procedure. In our study the effect of three different adhesive systems were evaluated with different application protocols in five sub-groups. Diamond bur grinding plus G-perimo universal adhesive agent applied group (16,5±0,79) were found to be statistically higher than the other groups (p: 0.00, p<0.05) while there was no statistical significant difference with diamond bur grinding plus clearfil SE bond self-etch adhesive applied group (15,91±1,15).On other hand, the shear bond strength values of diamond bur plus total-etch adhesive applied group (10,28±0,64) and air abrasion plus self-etch adhesive applied group (9,57±0,99) were found to be statistically lower than the other groups with a significant difference (p: 0.00, p<0.05).

Also, when comparing the subgroups within each other regardless type of surface treatments, the SBS values of the total-etch adhesive group (11,63±1,52) was found to be statistically significant lower than other sub-groups.Universal adhesive system has been introduced in field of restorative dentistry to be used in different fields such as bonding to composite resins, dental ceramic and other alloys.In the study of Kiomarsi N et al. they found that, the diamond bur surface treatment with subsequent application of the universal adhesive agent might enhance the repair bond strength of aged composite resin [31]. as G-perimo universal adhesive agent provide the highest value of shear bond strength, and this might contribute to the presence of functional monomer, like MDP and MDTP monomers which provide a high wettability of these adhesive systems [32].For the self-etch adhesive system (Clearfil SE Bond) which incorporate 10-MDP monomer in their formulation, these hydrophilic self-etching primers of this system might provide a good adhesion to the surface of aged composite through the reaction between the phosphate group of self-etch system and composite resin. Cavalcanti et al. concluded that, self-etch Clearfil SE bond system presented higher bond strength than three-step total-etch system (Single Bond). Furthermore, the active application technique used with self-etch adhesive system could have a positive effect on the re-bonding process [33].

For the total-etch adhesive system with etch- and -rinse protocol, the phosphoric acid etching permit elimination of the surface debris that cover the surface of old composite and might expose the underlying filler particle and these might increase composite surface wettability (34). However, the bonding agent of these system is more hydrophobic with high viscosity when compared to self-etch adhesive and universal adhesive and these might be attributed to low values of shear bond strength (35).According to the results in this study, it was found that the application of 37% phosphoric acid after grinding composite surface with diamond bur give negative effect on SBS values for all adhesive system, whereas with air abrasion, it gives a positive effect and these might be contributed to Acid etch might remove surface debris or incorporate air that reduces the surface area available for bonding after air-abrasion. with bur treatment, the acid-etching removes smear layer that is formed after bur grinding which might be more effectively penetrated or wetted with adhesive agents especially if silane is applied [36].The results of the assessment of the fracture type in the repaired specimens shown that, there was high percentage of cohesive failure within all groups and these might have contributed to The numerous air inclusions; as these air inclusions acts as stress points, thus giving a rise to the increased likehood of cohesive failure. the decrease in the cohesive strength of composite resin materials as a result of the aging process [37,38].

CONCLUSTION

The shear bond strength obtained by the mechanical surface grinding with diamond bur is statistically significant higher than that obtained with air abrasion surface treatment.The combination of universal adhesive system or two-step self-etch adhesive system and grinding with diamond bur for repair procedures provide the highest values of SBS.Two-step total-etch adhesive regimen produces lower bond strength when compared to other group regardless surface treatment used. The application of 37% phosphoric acid after grinding composite surface with diamond bur provide adverse effect on shear bond strength values with all adhesive systems, while with air abrasion surface treatment give a positive influence on the shear bond strength values.

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