

Evaluation of Shear Bond Strengths of Indirect Composite and Ceramic Restorations to Bleached Enamel

İndirek Kompozit Ve Seramik Restorasyonların Ağartılmış Mine Yüzeylerine Makaslama Bağlanma Dayanımının Değerlendirilmesi

ABSTRACT

Objectives: The aim of this study was to determine the shear bond strength of composite resin and lithium disilicate porcelain to bleached enamel 1 day or 2 weeks later using different adhesive resin luting cement.

Materials and Method: 84 flat enamel surfaces were prepared from freshly extracted non-carious human maxillary permanent incisors using low speed diamond saw. Specimens were randomly assigned to a control group (Group I) and two experimental bleaching groups according to the 1st day (Group II) or 2 weeks (Group III) after bleaching treatment with %30 carbamide peroxide (Zaris White&Brite, %30). Each group were divided into four subgroups (n=7); Group A: Specimens were luted to lithium disilicate blocks with light cure resin cement. Group B: Specimens were luted to composite resin blocks with light cure resin cement. Group C: Specimens were luted to lithium disilicate blocks with dual cure resin cement, Group D: Specimens were luted to composite resin blocks with dual cure resin cement. Surface preparations of the specimens and cementation procedure was done due to manufacturer's recommendations. Specimens were thermocycled 1000 times and shear bond strengths were determined using a universal testing machine. The data was evaluated using 3 way ANOVA and Tukey's HSD tests.

Results Control group (Group I) demonstrated significantly higher shear bond strength than bleaching groups (Group II & Group III) ($p<0.05$). In all subgroups. Group II shows the lowest scores. There were no statistically significant difference found among composite and ceramic material results. But as a luting agent; dual cure resin cement showed statistically significant lower shear bond strength values than light cure resin cement ($p<0.05$).

Conclusion: Bleaching significantly decreased bond strength. Bonding after 2 weeks demonstrated higher bond strengths than after 1 day. There was no statistically significant difference among luting agents in composite groups. Light cured resin cement showed better results than dual cured in ceramic groups.

Key Words: Bleaching, carbamide peroxide, shear bond strength, enamel, resin cements.

ÖZ

İşık yüzyıllardır iyileştirici bir ajan olarak kullanılmaktadır. Antik Yunanda güneş ışınları helioterapi amaçlı kullanılmış ve sağlığı bozulan insanlar güneş ışığına maruz bırakılmışlardır. Işığın bu iyileştirici etkisi günümüze değin gelmiş ve lazerler ile güneşten bağımsız tanı ve tedavi amaçlı kullanılmaya başlanmıştır.

1960'lı yıllardan beri oral ve maksillofasiyal cerrahi pratiğinde kullanılan

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lazerler artık rutin hale gelmiştir. Uyku apnesi, temporomandibular eklem bozuklukları, dental implantlar, premalign lezyonlar, posttravmatik skarların tedavisi, sert doku osteotomisi, yumuşak doku cerrahisi lazer cerrahisinin ortaya çıkmasıyla birlikte oldukça gelişmiştir.

Diğer geleneksel yöntemlere göre lazer uygulaması, lazer ışınının kolaylıkla yönlendirilebilmesi ve yüksek miktarda enerjinin küçük noktalara odaklanabilmesi nedeniyle oldukça ileri bir tedavi yöntemidir. Lazer teknolojisinin sağladığı yararların yanı sıra birtakım zararları da bulunmaktadır. Bu derlemede ağız diş ve çene cerrahisinde kullanılan argon, diyot, nd yag, ho yag, er yag, karbondioksit (co2), gibi sert lazer çeşitleri, kullanım alanları, etkinlikleri, lazer uygulamasının avantaj ve dezavantajları geniş bir derleme ile sunulmuştur.

Anahtar sözcükler: Ağartma, karbamid peroksit, makaslama bağlanma dayanımı, mine, rezin siman

INTRODUCTION

The aesthetic treatment of anterior teeth is an important aspect of prosthetic dentistry.¹ For aesthetic purposes, bleaching and laminating are recognized as simple, effective and inexpensive alternatives to fixed partial dentures. The bleaching treatment motivates patients to seek further esthetic dental treatments. When patients have their teeth bleached, they often become interested in aesthetic procedure such as, replacement of old restorations, closure of diastemas and applications of laminate veneers.² Bleaching can also be indicated before placement of an esthetic restoration to obtain well-matched final color.³

Carbamide peroxide is a bleaching agent that is very unstable and disassociate into hydrogen peroxide and urea.⁴ The hydrogen peroxide (HP) diffuses through enamel and dentin and breaks stain macromolecules into smaller fragments that are lighter in color, resulting in the bleaching effect.⁵

Using carbamide peroxide is the safe and cost effective bleaching technique that provides the best risk-benefit ratio.⁶ Higher concentrations of carbamide peroxide advocated for in-office bleaching techniques. These should be used with a rubber-dam or a tissue protector to prevent burns of soft tissue. Thirty five percent carbamide peroxide is effectively 10% HP. Hence, these in-office solutions are not as caustic as the conventional 30% HP solution generally used for in-office bleaching.⁴

The concept of bonding a material directly onto the enamel or dentin was explained some fifty years ago.^{7,8} Despite the popularity of using resin composite materials, their polymerization shrinkage during curing presents serious problems.⁹ In an attempt to find a solution to this, an indirect inlay technique has been developed.¹⁰

The clinical longevity of indirect restorations made of

ceramics or indirect composite resins depends on their successful treatment and cementation. The cementation technique is determined by the type of restorative material-ceramics or indirect composite resins; thus, their intaglio surface treatment should be performed according to their particular compositions.¹¹ The most critical step in the process is the seating of the porcelain laminate veneers. Both appearance and durability can be affected if mistakes are made in this phase of treatment.¹² The use of resin luting agents has been encouraged for cementation of laminate veneers because of their high bond strength and good esthetics. Dental resin cements are generally composites, which provide one or more polymerization modes; light, chemical or dual.^{13,14} Visible light-cured systems are appropriate where light can penetrate through the restoration, since adequate light is needed to ensure optimal polymerization.¹⁵ Chemical-cured systems are able to uniformly set even at the bottom of deep cavities, where access for light-curing is limited.¹⁶ Dual-cure versions were developed in an attempt to combine the most desirable properties of the light- and chemical- cured systems.¹⁷

RelyX Veneer cement is a light-cure, methacrylate resin-based luting material. RelyX Veneer cement is a single component, light-cure material packaged in a single syringe. It is designed to be used in conjunction with Single Bond or Scotchbond multi-purpose dental adhesive systems.¹⁸

RelyX™ ARC Adhesive Resin Cement is a permanent, dual-cure, paste-paste resin cement developed to be used with the 3M Single Bond dental adhesive system. Both luting cements were used in this combination, the system is indicated for bonding indirect restorations.¹⁹

Resin cements provide adequate bond strength between enamel and indirect restorations. However, some studies have shown that the bond strength of indirect adhesive restorations to enamel are reduced when the tooth has been bleached with carbamide peroxide. It is

reported that this situation is related to the presence of residual peroxide, which interfered with the resin attachment and inhibited the resin polymerization.²⁰ But some of the studies showed that the bond strength returned to normal values when the bonding procedures are applied after a time lapse. The aim of this study was to determine the shear bond strength (SBS) of composite resin and ceramic to bleached enamel 1 day/2weeks after using different adhesive resin luting cements.

MATERIALS AND METHODS

84 freshly extracted non-carious human incisors which were extracted because of bone resorption or sever periodontitis; were cleaned, pumiced and washed under water. Then the teeth were embedded in auto polymerizing acrylic resin (QC 20, Dentsply Weybridge Limited, England). Specimens were assigned to a control group and two experimental bleaching groups according to the treatment 1 day or 2 weeks after bleaching. Each group were randomly divided into four subgroups;(n=7) (Table 1). G1: Ceramic blocks (CB) (IPS Empress II, Ivoclar-Vivadent, Schaan, Liechtenstein.) luted with light-cured resin (LC) (Rely X Veneer, 3M, ESPE, St Paul, MN, USA) luting cement. G2: Composite resin blocks (CRB) (Filtek Supreme XT, 3M ESPE, St Paul, MN, USA) luted with LC. G3: CB with dual-cured resin (DC) (Rely X ARC, 3M, ESPE, St Paul, MN, USA) luting cement, G4: CRB luted with DC. (Table I)

Table I:The control and experimental groups which were used in the study.

Control group	Experimental group	
No bleaching(n=28)	Post bleaching interval (n=28)	Post bleaching interval 2 weeks (n=28)
G1	G1	G1
G2	G2	G2
G3	G3	G3
G4	G4	G4
Subgroups	Ceramic blocks: IPS Empress II	Composite resin blocks: Filtek Supreme XT
Light cured resin luting cement Rely X Veneer	G1 (n=7)	G3 (n=7)
Dual cured resin luting cement- Rely X ARC	G2 (n=7)	G4 (n=7)

42 lithium disilicate-reinforced glass infiltrated ceramic blocks were fabricated from a heat-pressed ceramic (IPS Empress II, Ivoclar Vivadent, Schaan, Liechtenstein.) blocks according to the manufacturer's instructions. Wax models (2mm thickness, 10 mm in diameter) were prepared and heatpressed with the ceramic material using the lost wax technique.

42 composite resin blocks (Filtek Supreme XT, 3M ESPE) were fabricated by using teflon mold according to the manufacturer's instructions (Fig. 1). Filtek Supreme XT is indicated for direct and indirect anterior veneers, inlays and onlays.



Figure 1:The teflon mold

In bleaching groups %30 carbamide peroxide office-bleaching gel system (Zaris White & Brite, %30, 3M ESPE) was used. Bleaching treatments were performed in %100 humidity at 37° C.

Bleaching gel was applied to the enamel surfaces for 30 minutes. Then the specimens were rinsed with an air-water spray. This process was repeated for 3 sessions and the intervals between the sessions were one week. The distilled water was changed in every sessions. Specimens of the control group were not bleached but stored in distilled water at 37° C in this process.

Flat enamel surfaces were prepared from using low speed diamond saw under running water. Before bonding procedures, teeth were etched with 37% phosphoric acid and then total etch adhesive bonding agent (Single Bond, 3M ESPE) was applied according to manufacturer's recommendations, 2mm thick composite blocks and ceramic blocks were etched (HF, 3M, ESPE) and silanated with porcelain silan (Rely X ceramic primer, 3M ESPE). Then a layer of luting cement, about 1 mm thick, was bonded on each enamel specimens.

Specimens were subjected to 1000 thermocycles between the baths of 5° C and 55° C, with a dwell time of 30 seconds. Shear bond strengths were determined using a universal testing machine (Lloyd Instruments, UK). Specimens were mounted in a jig of the universal testing machine and a knife-edge shearing rod was applied to the composite/tooth or ceramic/tooth interface until fracture occurred (Fig. 2)

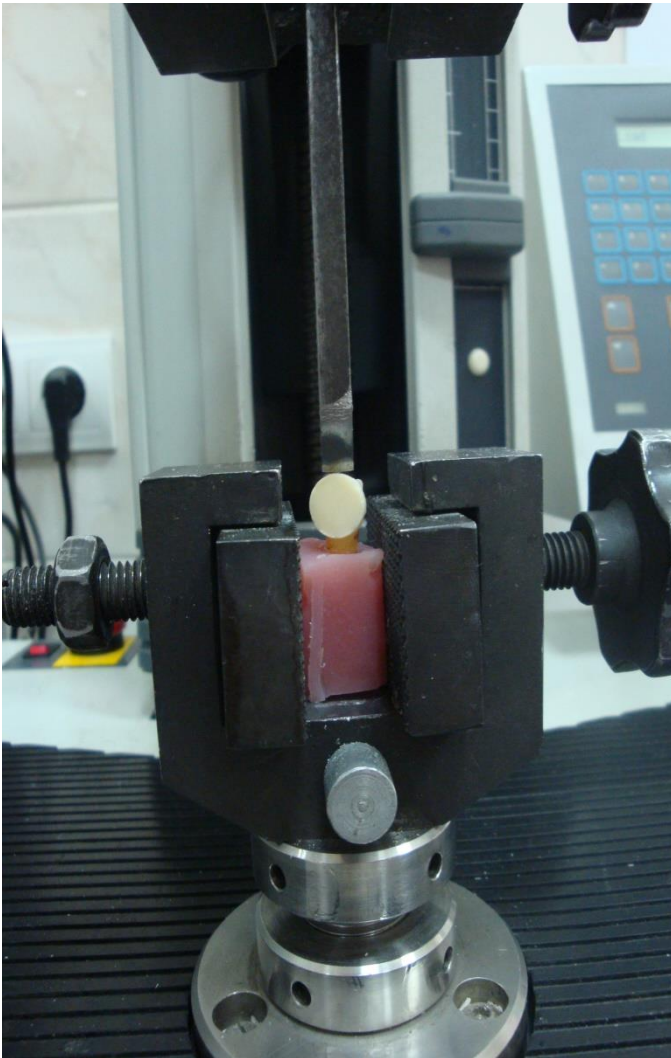


Figure 2.:Specimens were mounted in a jig of the universal testing machine and a knife-edge shearing rod was applied.

The specimens were loaded at a crosshead speed of 0.5mm/min. Loads were recorded in N. The load at the failure was divided by the bonding area to express the bond strengths in MPa.

RESULTS

The mean SBS values of the specimens and standart deviations are shown in Table II.

The statistical analysis was done by using three-way analysis of variance(ANOVA) and Tukey's HSD test for multiple comprasions. Control group (Group I) demonstrated significantly higher shear bond strength than bleaching groups (Group II & Group III) ($p<0.05$). In all subgroups, Group II shows the lowest scores. There were no statistically significant difference found among composite and ceramic material results. But as a luting agent; Rely X ARC showed statistically significant lower shear bond strength values than Rely X Veneer ($p<0.05$)

Among G III and G IV composite subgroups, there were no statistically significant differences dependent on luting agents. But in G1 and G2 ceramic subgroups, Rely X Veneer showed statistically significant higher shear bond strength values than Rely X ARC ($p<0.001$) (Graphic1).

The fracture modes of each group are shown in Tables III-V. The contol group (G I) showed the highest cohesive fractures Group II had high number of adhesive type fractures and had the lowest bond strength values. Group III reported primarily mixed and adhesive fractures

DISCUSSION

Porcelain veneers are excellent for correcting severe color problems that are used when the defects on the facial surfaces are generalized. Bleaching can be attempted first to assess the potential for whitening of the teeth. If bleaching is succesful porcelain veneers may not be necessary. Even if the color is lightened slightly, it may be sufficient to eliminate the use of opaque porcelains or opaque cements in the final restorations to mask the existing discoloration.³ As with the ceramic materials, composite resins also present satisfactory characteristics such translucence, surface polishing, resilience, and positive esthetics (21).

The previous studies have focused on the effect of bleaching agents on the bond strength of restorative materials directly bonded to enamel. Various types of bleaching agents were used to investigate the bond strength of composite resins, resin modified glass ionomer and conventional glass ionomer cements to enamel and dentin (22-25).

Table II.:The mean and standart error results of the materials tested in the study

<i>Grup</i>	<i>Material</i>	<i>Luting Agent</i>	<i>Mean</i>	<i>Std Error</i>	<i>Lower Bond</i>	<i>Upper Bond</i>
Control- No bleaching GROUP I	Ceramic	RelyX Veneer(G1)	5.677	.701	4.163	7.187
		RelyX ARC(G2)	5.207	.701	3.698	6.717
	Composite	RelyX Veneer(G3)	5.123	.701	3.725	6.520
		RelyX ARC(G4)	4.571	.701	3.174	5.969
Post bleaching interval: 1day GROUP II	Ceramic	RelyX Veneer(G1)	5.092	.701	3.694	6.489
		RelyX ARC(G2)	2.357	.701	.959	3.754
	Composite	RelyX Veneer(G3)	3.369	.701	1.971	4.766
		RelyX ARC(G4)	3.299	.701	1.901	4.696
Post bleaching interval: 2 weeks GROUP III	Ceramic	RelyX Veneer(G1)	6.693	.701	5.296	8.091
		RelyX ARC(G2)	3.187	.701	1.789	4.584
	Composite	RelyX Veneer(G3)	3.505	.701	2.108	4.903
		RelyX ARC(G4)	4.005	.701	2.607	5.402

Table III : The fracture modes of Grup I (Control).

Grup I (Control)	Adhesive	Cohesive	Mix
G1	2	2	3
G2	2	4	1
G3	4	2	1
G4	2	5	-

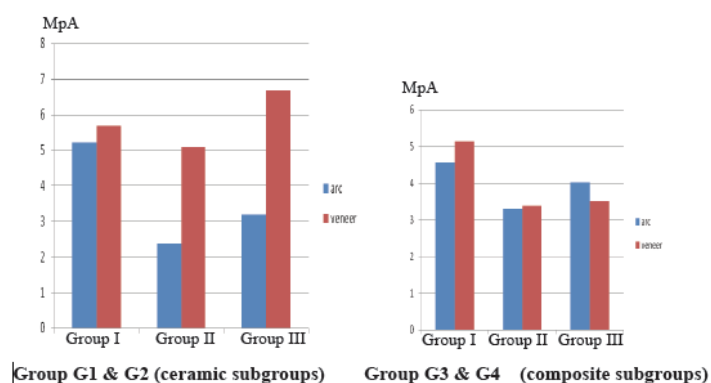
Table IV : The fracture modes of Grup II (1st day)

Grup II (1 st day)	Adhesive	Cohesive	Mix
G1	7	-	-
G2	5	1	1
G3	5	1	1
G4	4	1	2

Table V : The fracture modes of GrupIII (2 weeks)

GrupIII (2 weeks)	Adhesive	Cohesive	Mix
G1	3	1	3
G2	3	2	2
G3	2	3	2
G4	3	-	4

Graphic1 : Shear bond strength values of luting agents.



There are few studies to investigate the effect of bleaching treatment on bond strength of indirect restorations to dental hard tissues by using resin cements(26,27).This study compared the shear bond strength of composite and ceramic blocks to human enamel which was bleached one day or two weeks delayed by using light-cure and dual cure resin luting cement.

Of major interest to the restorative dentist is the observation with all bleaching techniques that there is a decrease in bond strength between composite resin and bleached, etched enamel (28).This affect also has been demonstrated with carbamide peroxide (29,30).

Removing the superficial layer of enamel or roughening of the enamel surface may also eliminate the effects of the peroxide on bond strengths.31 However, Wilson et al reported that pre-bleaching surface treatments, forming a flat enamel surface by polishing with sand paper, had no effect on bond strength.32 In this study we roughened the enamel surface with diamond saw under running water to mimic the conditions of clinical practice.

Several authors have reported a significant decrease in the bond strength of composite resin to CP-bleached enamel when compared with unbleached enamel (25,33,34,35,36,37). Hydrogen peroxide-releasing agent may result in significant decrease of enamel calcium and phosphate content and in morphological changes in the superficial enamel crystallites. 38,39 Moreover, acid etching of bleached enamel surface produced loss of prismatic form resulting in an enamel surface which appeared to be over-etched.40 The immediate but transient reduction in bond strength may also attributed to residual oxygen remaining near the enamel surface.According to some authors, the oxygen might interfere with the polymerization of adhesive systems (25,38,41,42,43,44,45). Recommendations for

application of composite materials onto carbamide peroxide bleached enamel range from 1day, 3-7 days to 3 weeks(25,37,41,46,47).

In this study, bonding after 2 weeks demonstrated higher bond strengths than after 1 day in all groups. There was no significant differences found between unbleached and 2 weeks delayed groups. Wilson et al also reported that bleaching significantly decreased bond strength at day 1, but after 2 weeks, bleaching had no significant effect on bond strength (32).

There are many studies that support that bleaching with carbamide peroxide does not reduce the bond strength of resin to enamel after 2 weeks (32,48). In 2 weeks delayed bleaching group, storage in saline solution may have removed the residual oxygen from the enamel surface.

For primary evaluation of mechanical and chemical properties or bonding behavior of dental resin cements a-24 hour storage condition may be sufficient (49). Due to this reason all specimens were stored in distilled water for one day before shear bond testing.

When the composite (Filtex Supreme XT) is used as an indirect restorative material, there is no statistically significant difference among luting agents. Rely X ARC and Rely X Veneer showed similar results. Bleaching after one day or two weeks reduced bond strength.

When the ceramic material (IPS Empress II) is the materials of choice, Rely X Veneer showed statistically better results than Rely X ARC ($p=0.001$). Unlike Rely X Veneer, Rely X ARC has a chemically polymerization phase. The oxidative products of bleaching may affect this chemical reaction. due to different activating system, dual cure resin cement may showed lower results than light-cure resin cement. Bleaching significantly decreased bond strength at day one but after two weeks, bleaching showed no statistically significant effect on bond strength of ceramic-tooth interface.

When the SBS values of our test groups were compared with the others in literature, the scores in this study were lower than the others, because the sample size that is the surface area of the samples are larger than those.

Failure analysis showed mainly adhesive failure at the resin-composite/ceramic-enamel surface interfaces for the bleached groups. So the surface area seems to be the weak link of the bond. This findings supported the assumption that the adhesion of resin to bleached enamel and also the properties of the adhesively attached resin are negatively affected by the bleaching procedure performed before bonding.

Micro tensile bond strength (MTBS) and shear bond strength (SBS) are available in vitro methods that are analyzed the bond strengths to tooth surface. 50 When compared to MTBS test, SBS test is easy to perform. Nevertheless it has to be taken into account that with increasing bond strength values, the chance for cohesive failures with fractures increases due to a non-uniform load distribution.51 MTBS or SBS testing alone might not provide actual data concerning the bond strengths of materials (52).

In Gokçe et al (26) also compared the SBS of resin luting agent to enamel after bleaching with carbamide peroxide. In that study, unbleached and one week delayed bonded enamel groups showed mainly mixed fractures when the number of adhesive fracture modes was high in the immediately bonded after bleaching group. Comlekoglu et.al (27) investigated the effect of carbamide peroxide bleaching on the SBS of luting resin to dentin. Unbleached group reported primarily mixed fractures, immediately bonded group showed the highest number of adhesive fracture modes and the lowest mean SBS value while treated with antioxidant agent groups had a high number of cohesive type fractures and the highest SBS values.

Rahul et.al reported that using 10% CP 24 h before bonding does not significantly alter SBS values of ceramic, and composite brackets to enamel but it is preferable to use ceramic brackets than composite brackets for bonding 24 h after bleaching. 53 Oztaş et.al also indicated that %20 CP bleaching did not significantly affect the shear bond strength of ceramic orthodontic brackets bonded with chemically or light-cure composite resin to enamel when bonding occurred 24 hours or 14 days after bleaching (54).

According to the results of this study, the SBS of indirect restorations and bleached enamel after day 1 day showed the lowest scores, and higher adhesive fractures but after 2 weeks groups showed similar scores when they are compared with unbleached control group. This might be explained by storing samples in saline solution might have contributed to the removal of the residual oxygen from the enamel surface during the immersion process. Further investigations should be done with a large number of samples.

CONCLUSION

On the basis of the findings and within the limitation of this in vitro study, it may be concluded that;

1. Bleaching significantly reduced shear bond strength of

indirect resin composite and ceramic restorations after 1 day but not after 2 weeks($p \leq 0,05$).

2. Bond strength after 2 weeks was higher than after 1 day.

3. There is no significant differences found between unbleached and 2 weeks delayed groups.

4. There is no statistically significant difference among luting agents in composite groups. Rely X ARC and Rely X Veneer showed similar results. Bleaching after one day or two weeks reduced bond strength.

5. Rely X Veneer showed statistically better results than Rely X ARC in ceramic groups ($p \leq 0,001$). Bleaching significantly decreased bond strength at day one but after two weeks, bleaching showed no statistically significant effect on bond strength of ceramic-tooth interface.

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