



Dentin Shear Bond Strength of 5th and 7th Generation Adhesives Co-Cured with Preheated Composite Resin

Timur V. Melkumyan

Tashkent State Dental Institute, Tashkent, Uzbekistan

Peoples' Friendship University of Russia (RUDN University), Moscow, Russia

Surayo Sh. Sheraliava

Tashkent State Dental Institute, Tashkent, Uzbekistan

Shahnoza K. Musoshayhova

Tashkent State Dental Institute, Tashkent, Uzbekistan

Diyoraxon A. Inoyatova

Tashkent State Dental Institute, Tashkent, Uzbekistan

Angela D. Dadamova

Tashkent State Dental Institute, Tashkent, Uzbekistan

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Abstract

Co-curing adhesives with composite resins can simplify restorative procedures and reduce film thickness, but attenuation of light and polymerization shrinkage stress often lead to compromised bond strengths. While preheating composite material improves its flowability and degree of conversion, rapid thermal dissipation during clinical handling remains a significant limitation. This study aimed to investigate the synergistic effect of simultaneous preheating and co-curing techniques on dentin bond strength, utilizing both total-etch (5th-generation) and self-etch (7th-generation) adhesive systems.

Methods: Eighty human teeth specimens with exposed flat dentin surfaces were divided into two main experimental groups depending on the adhesive system used: 5th-generation total-etch (OptiBond Solo Plus; Kerr) and 7th-generation self-etch (Bond Force II; Tokuyama). Each group was further subdivided into two subgroups (n = 30) based on the curing protocol: conventional sequential polymerization versus simultaneous co-polymerization with a composite resin (Herculite XRV; Kerr) that was preheated (40-43 °C) directly on the tooth surface using a specialized metal heating device. Shear bond strength (SBS) was measured using an UltraTester testing machine at a crosshead speed of 1 mm/min. Data were recorded in pounds and converted to megapascals (MPa), followed by statistical analysis using Student's t-test (p < 0.05).

Results: Co-polymerization of the preheated composite with the 5th-generation adhesive system significantly decreased the SBS to dentin by 1.3-fold compared to conventional sequential polymerization (p < 0.05). Conversely, co-polymerization of the preheated composite with the 7th-generation self-etch adhesive resulted in a significant 1.2-fold increase in SBS (p < 0.05). Under the co-polymerization protocol, no statistically significant differences were observed between the two adhesive types.

Conclusions: The impact of combining preheating and co-curing protocols is strictly dependent on the adhesive system generation. Direct in situ heating of a composite resin over a self-etch adhesive significantly enhances its bonding performance, likely due to enhanced chemical interaction between monomers and tooth hydroxyapatite, whereas it impairs the performance of total-etch systems.

Keywords: Shear bond strength; preheated composite; co-curing; self-etch adhesive; total-etch adhesive; dentin bonding.

Introduction

In dentistry, co-curing is defined as the simultaneous polymerization of adhesive resin monomers with a composite material used for direct restorations, or with a composite cement intended for adhesive luting of indirect restorations (1, 2).

One of the key advantages of this technique is the formation of a thinner adhesive layer compared to the conventional approach, which involves sequential polymerization of the adhesive and composite. The adaptation of a more viscous composite material, or the placement of indirect restorations onto a tooth surface covered with uncured adhesive, promotes additional spreading of the adhesive and its simultaneous absorption into the composite mass. Furthermore, this method significantly reduces application time and simplifies the restorative procedure (1, 3).

However, according to numerous studies, co-curing may lead to a reduction in adhesive bond strength when compared to the conventional technique. This is often attributed to a lower degree of conversion of adhesive resin monomers due to attenuation of light intensity as it passes through the restorative material. Additionally, there is evidence suggesting that the thin adhesive layer exhibits insufficient elasticity and inadequate strength to withstand the polymerization shrinkage stress generated within the composite material during curing (4).

Thus, achieving a thin yet durable adhesive layer remains a relevant challenge in restorative dentistry. It has previously been established that the strength of polymeric bonds is largely determined by their degree of conversion, which is significantly influenced by temperature (5). Nevertheless, most adhesive systems are recommended to be stored at temperatures between +2 °C and +25 °C. It is also known that reduced pulpal microcirculation associated with the use of vasoconstrictor-containing anesthetics and rubber dam isolation may decrease enamel and dentin temperatures to approximately 26 °C (6).

To enhance the degree of conversion of adhesive monomers, preheating immediately prior to application has been proposed. However, experimental findings remain inconsistent. This inconsistency is primarily due to increased instability of adhesive systems at elevated temperatures, caused by the volatility of certain components, particularly solvents and photoinitiators (7, 8). Moreover, exceeding temperatures above +25 °C may initiate spontaneous polymerization of adhesive monomers, increasing viscosity and impairing their adaptation to cavity walls.

A potentially optimal solution may involve the use of preheated composite material during co-curing with adhesive resin monomers, due to possible heat irradiation and in situ temperature elevation. However, rapid heat loss during transfer from the heating device and subsequent placement onto the prepared surface may reduce the beneficial effects of preheating (9).

Therefore, heating the composite material directly on the

surface to bond may provide the most favorable conditions for achieving a higher degree of conversion of both composite and adhesive resin monomers.

In light of the existence of two main concepts in adhesive dentistry and the lack of data evaluating the effectiveness of composite heating directly on the adhesive-coated tooth surface after placement, the aim of the present study was to investigate the combined effect of preheating and co-curing on the bond strength of composite material to dentin using both total-etch and self-etch adhesives.

Material and methods

Non-carious third molars extracted for orthodontic purposes were used in this study. Processing of tooth samples for in vitro laboratory evaluation was initiated after obtaining informed consent from all patients.

Adhesive bond strength was evaluated on 120 specimens, which were stored in an incubator at a temperature of 26 °C before usage. All samples were randomly assigned into two groups (n = 60 each). Specimens in Group 1 underwent co-curing of the composite material with the adhesive resin, whereas in Group 2, the adhesive and composite materials were polymerized sequentially.

All specimens were prepared according to the Ultra-Test method (Ultradent Products, Inc., USA) for shear bond strength evaluation. To standardize the smear layer, dentin surfaces of all samples were polished using silicon carbide abrasive paper with progressively increasing grit sizes from 300 to 600.

Depending on the adhesive system used, each group was further divided into two subgroups (n = 30) based on the adhesive system applied: OptiBond Solo Plus (OSP; Kerr, Italy) for subgroup A, and Bond Force II (BF II; Tokuyama, Japan) for subgroup B.

Composite cylinders were fabricated on the dentin surfaces using a universal composite resin (Herculite XRV; Kerr, Italy). Each tooth specimen with an exposed bonding area was secured in a specialized clamp. A preheated composite material (40–43 °C) was then applied on adhesive surface using a standardized metal tube embedded in a plastic holder designed to facilitate contact heating.

Light activation was performed using the VALO X curing unit (Ultradent Products, Inc., USA) in standard mode, in accordance with the manufacturer's instructions. Composite preheating was carried out using a custom-designed heating device. Temperature control was performed using a thermal imaging camera (UNI-T UTi260A, Uni-Trend Technology, China).

The shear bond strength (SBS) of the composite to dentin was measured using an UltraTester testing machine (Ultradent Products Inc., South Jordan, UT, USA) at a crosshead speed of 1 mm/min. The maximum load at failure was recorded in pounds (lb) and subsequently converted to megapascals (MPa).

Statistical analysis was performed using Statistica software (v.12.0; StatSoft Inc., Tulsa, OK, USA). The normality of the data distribution was assessed using the Shapiro-Wilk test. Descriptive statistics were expressed as mean values (M) and standard deviations (SD). Continuous variables between the groups were compared using Student's t-test. Statistical significance was set at $p < 0.05$.

Results

Comparative analysis of the obtained data (Table) revealed that co-curing of the preheated composite with the 5th-generation adhesive system significantly decreased the

shear bond strength (SBS) to dentin by 1.3-fold compared to conventional polymerization ($p < 0.05$). Conversely, co-curing of the preheated composite with the 7th-generation adhesive system resulted in 1.2-fold increase in SBS compared to the conventional technique, but not significantly ($p > 0.05$).

Between the subgroups, significant differences in SBS were observed only during sequential polymerization of the adhesive and the preheated composite. When the co-curing method was applied, no significant differences were found between the subgroups; this was attributed to a decrease in SBS for OptiBond Solo Plus and an increase in efficiency for Bond Force II.

Table. Shear bond strength (MPa) of the composite material to dentin across different adhesive groups.

Groups	1 st (n=60)	<i>P</i>	2 nd (n=60)
A (n=30)	18.4 ± 2.3	<0.05	26.3 ± 3
<i>P</i>	>0.05		<0.05
B (n=30)	21.8 ± 3.8	>0.05	18.1 ± 2.5

Discussion

The available literature presents controversial data regarding the advantages and disadvantages of co-curing and preheating techniques. However, no prior studies have addressed their simultaneous application. Furthermore, the co-curing of a self-etch adhesive with a composite resin preheated immediately after its adaptation to the tooth surface has not been previously evaluated.

Therefore, the primary objective of this laboratory study was to develop a model capable of evaluating the shear bond strength under the condition of composite heating to the target temperature immediately prior to photo-activation. This approach revealed an enhanced efficacy of the 7th-generation adhesive system, contrastingly accompanied by a reduced performance of the 5th-generation system during co-curing with the preheated composite. Additionally, it was hypothesized that heating the composite material on the dentin surface coated with a self-etch adhesive promoted the chemical bonding between the resin monomers and tooth hydroxyapatite.

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