# Study of Microshear Bond Strength of Adhesive Resin Composite Bonded to Dentin Irradiated by Different Diagnostic Imaging Modalities

Ola. M. Sakr[1]

[1]Department of Conservative Dentistry, College of Dentistry, Qassim University, Kingdom of Saudi Arabia.

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## ABSTRACT

**Background**: The aim of this in vitro study was to evaluate the microshear bond strength of totally etched and bonded dentin to Filtek Z350 XTnanofilled resin composite subjected to different diagnostic imaging systems. **Methods**: Forty extracted molars conducted in this study, were sectioned mesiodistally with a diamond bur. The inner surface of each tooth dentin was ground flat with SiC abrasive papers. The roots of the sectioned teeth were mounted in a cylindrical mold using chemically cured acrylic resin. In (group 1) non exposed resin composite (control), (group 2) samples exposed to conventional periapical x ray machine , in (group 3) : samples exposed to digital x ray system and in (group 4) : samples exposed to cone beam computed tomography system ( CBCT).Each acrylic embedded molar tooth with its own bonded composite micro-cylinders was tested for microshear bond strength using NEXYGEN from Lloyd Instruments. Bond strength values were calculated as MPa and the results were evaluated statistically using repeated measures of two-way ANOVA, with significance set at $p < 0.05$. **Results**: Imaging irradiation systems affected adhesion of nano filled composite to dentin in all tested groups. CBCT group showed the statistically significantly highest mean micro-shear bond strength. There was no statistically significant difference between periapical machine, Control and Digora system groups; all respectively showed the statistically significantly lowest mean micro-shear bond strength values. **Conclusion**: Repeated periapical irradiation may negatively affect bond strength of dentin to present composite restoration.

***Keywords:*** Imaging modalities, µ - Shear bond strength, dentin bonding, radiation.

## INTRODUCTION

Dental imaging is a helpful aid in the diagnosis of maxillofacial lesions. Although it is based on delivering a minimum radiation dose to the lesion, the most orofacial complications are dose dependent.[1] In dental practice, vital tissues are inevitably irradiated as sound, carious, sclerotic tissues, or restored teeth. However, several studies have reported alteration of the oral hard tissues after radiation,[2-8] Which may affect on bond strength of present restorations .It was found that in irradiated dentin, significant reduction inhardness,[4,6] stability of the amelodentinal junction and wear resistance have been described.[3,7] Furthermore, it has been reported that irradiation damage of collagen fibrils could interfere with the bond strength to dentin.[2,7] Other researchers stressed on that doses of irradiation may have significant side effects on the mechanical behavior of bone and dentin. The effect of irradiation on bone and dentin is not completely understood; however, it is theorized that irradiation most likely affects the collagen and its interaction with the mineral, a carbonated biological hydroxyapatite (HAP). Collagen, the proteinaceous phase of bone and dentin, acts as a viscoelastic material allowing hard, collagen-based biological materials such as bone and dentin to be tough and crack resistant.[8-10] The change in interfacial strength and collagen mechanical properties due to high irradiation doses results in a reduction of fracture toughness, ultimate strength, work to failure, bending strength, impact energy absorption, and fatigue failure.[10-12]

**Name & Address of Corresponding Author**
Dr. Ola. M. Sakr,
Department of Conservative Dentistry,
College of Dentistry, Qassim University,
Kingdom of Saudi Arabia.

Cone beam computed tomography (CBCT) is a new technology that can provide sagittal, coronal and axial images with sub-millimeter resolutions. The radiation dose is lower than conventional CT. CBCT has been used in several dental diagnostic areas including implant placement, temporomandibular joint examination, endodontic treatment, orthodontics and periodontology. Moreover, CBCT appears to be a promising tool for assessing already-observed small carious lesions and the hidden caries beneath a sound surface.[13] Little is known about the effects of different imaging radiation systems on composite restorations, for instance, whether they have a shorter clinical service life than non-irradiated restorations. Moreover, the literature lacks studies which address the combined effect of repeated radiation doses on the bond strength of composite restorations.

The aim of this in vitro study was to evaluate the microshear bond strength of totally etched and bonded dentin to Filtek Z350 XTnanofilled resin composite subjected to different imaging radiation system. The hypothesis tested was that the different imaging radiation systems would interfere with the bonding to dentin.

## MATERIALS AND METHODS

### 1. Specimen Preparation

A total of 40 caries-free permanent molars were used in this study. Individual tooth surfaces were hand scaled to remove any remaining soft tissue. All teeth were stored in distilled water at -20°C. Specimens were sectioned mesiodistally with diamond burs under water cooling. The inner surface of each crown dentin was ground flat with 200-, 400-, and 600-grit silicon carbide abrasive papers. Superficial occlusal dentin surfaces were cleaned with water spray for 5 seconds and dried with small cotton pellet. Details of bonding adhesives and composite are provided in [Table 1]. Prior to application of the bonding resin on each specimen, hollow cylinders 2.0 mm in height were cut from micro-bore tygon tubing (Norton Performance Plastic; OH, USA) with an internal diameter of 0.75mm and were placed on the treated surfaces. Each adhesive system was applied according to the manufacturer's instructions as follows: The dentin surface was etched (using Scotchbond) for 15 s with 37% phosphoric acid, and rinsed with water spray for 15 s. Excess water was removed with cotton pellet or mini sponge leaving the dentin moist. Bond (Adper Single bond 2) was applied with a disposable brush, 2 to 3 consecutive coats for 15 s with gentle agitation using a fully saturated applicator. Gently air thin for five seconds in evaporative solvents. Light cured for 10 s using a halogen light source (Visulux curing unit, Vivadent; Schaan, Liechtenstein). The output of the light curing unit was regularly checked (500 mW/mm2). A nanofilled restorative composite (Filtek Z350 dentin Shade A2, 3M, USA) was carefully inserted into the tubing lumens and irradiated for 40 s according to the manufacturer's instructions. The specimens were then stored in artificial saliva at 37°C for 24 hrs. After removal from artificial saliva, the tygon tubing around composite cylinders was removed by gently cutting the tube into two hemi cylinders using a feather-edge blade. The teeth were then mounted in a cylindrical mold using chemically cured acrylic resin (Epofix Resin, Struers, and Copenhagen, Denmark). Their long axes were positioned perpendicular to the base of the molds.

**The samples were randomly assigned into 4 groups (n =10), as follows:**

**Group 1:** control group (non-irradiated samples)

**Group 2:** samples were subjected to conventional periapical x ray machine 4 times as one exposure / a week interval.

**Group 3:** samples were irradiated with Digital periapical imaging system (Digora).

**Group 4:** samples were irradiated with Cone beam computed tomography (CBCT) scanner.

**Table 1: Composition, lot number, and manufacture of the tested materials.**

| Material | composition | Lot number | Manufacture |
|---|---|---|---|
| Scotchbond etchant gel | 35 % phosphoric acid | N 110268 | 3M ESPE |
| Adper Single bond 2 | (10% colloidal nanofiller) BisGMA, HEMA, dimethacrylates, ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids | N353034 | 3M ESPE |
| Filtek Z350 XT | (20 nm silica filler 4-11 nm zirconia filler) as 72.5% by w filler bis-GMA, UDMA,TEGDMA , PEGDMA and bis-EMA resins | N339145 | 3M ESPE |

### 2. Radiation Application:

- Conventional periapical radiography was performed at faculty of oral and dental medicine, Cairo University, Oral and Maxillofacial radiology department using Soredex – MINRAY-Finland with dental mode at (70) kv, (840) mAs, (0.32) seconds. Films were processed using an automatic processor (Kodak products, USA), dried and archived in a filing system to be interpreted at the end of the clinical work. [Figure 4]
- Digital periapical radiography was performed at faculty of oral and dental medicine, Cairo University, Oral and Maxillofacial radiology department using DIGORA® Optime - Imaging plate systems(PSP) - soredex-Finland with dental mode at (70) kv, (840) mAs, (0.08)seconds. [Figure 1,4]
- CBCT scanning was performed at the 3D Diagnostix DENTAL IMAGING CENTERS using (i-CAT) Image Sciences International Hatfield, Pa USA , The sagittal, coronal, axial and 3D images were obtained using dental mode at (120) kV, (5) mA,(4) seconds. Images were obtained by volume data of cone type with a field size of (49-60) mm. [Figure 2,5]

**Figure 1: Soredex Digora system.**

**Figure 2: CBCT (i-CAT) scanner used in the study.**

3. **Microshear bond strength testing:**
These tests were performed using NEXYGEN from Lloyd Instruments. [Figure 3]
Each acrylic embedded tooth with its own bonded micro-cylinders was secured with tightening screws to the lower fixed compartment of a materials testing machine (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) with a loadcell of 5 kN and data were recorded using computer software (Nexygen-MT Lloyd Instruments). A loop prepared from an orthodontic wire (0.014” in diameter) was wrapped around the bonded micro-cylinder assembly as close as possible to the base of the microcylinder and aligned with the loading axis of the upper movable compartment of the testing machine.
A shearing load with tensile mode of force was applied via materials testing machine at a crosshead speed of 0.5 mm/min. The relatively slow crosshead speed was selected in order to produce a shearing force that resulted in debonding of the microcylinder along the substrate-adhesive interface. The load required to debonding was recorded in Newton.

4. **Micro-Shear bond strength calculation:**
- The load at failure was divided by bonding area to express the bond strength in MPa:
$\tau = P/ \pi r2$
Where; $\tau$ =bond strength (in MPa), P =load at failure (in N)
$\pi$ =3.14, r = radius of micro-cylinder (in mm)

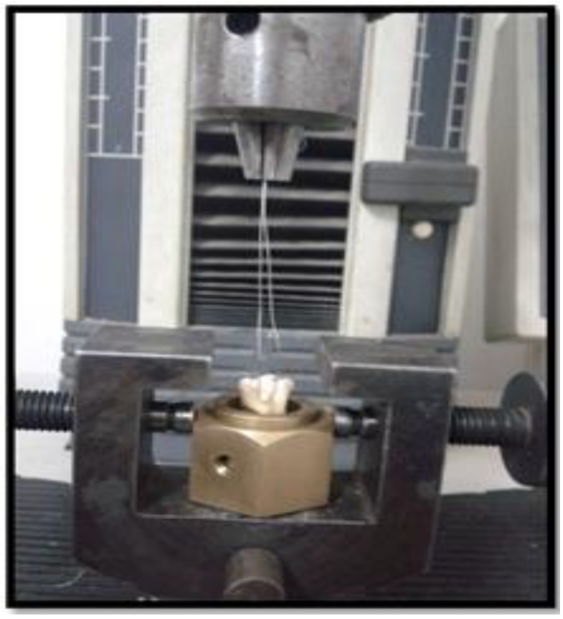

**Figure 3: Lioyd universal testing machine**

5. **Statistical Analysis:**
Numerical data were explored for normality by checking the distribution of data, calculating the mean and median values as well as using the tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Data showed non-parametric distribution and were presented as mean, median, standard deviation (SD) and range values. Kruskal-Wallis test was used to compare between the four groups. Mann-Whitney U test was used for pair-wise comparisons when Kruskal-Wallis test is significant. Bonferroni’s adjustment was performed for pair-wise comparisons.
The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

## RESULTS

CBCT group showed the statistically significantly highest mean micro-shear bond strength. There was no statistically significant difference between Control, periapical machine and Digora system groups; all respectively showed the statistically significantly lowest mean micro-shear bond strength values.$P \leq 0.05$. [Figure 6]

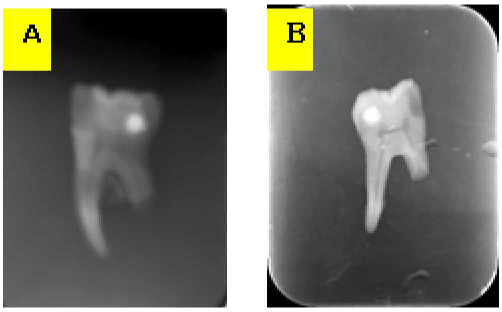


**Fig.(4)** *Showing one of our studied sample molar which was irradiated with different imaging systems, a) conventional periapical radiography, b) digital periapical radiography.*

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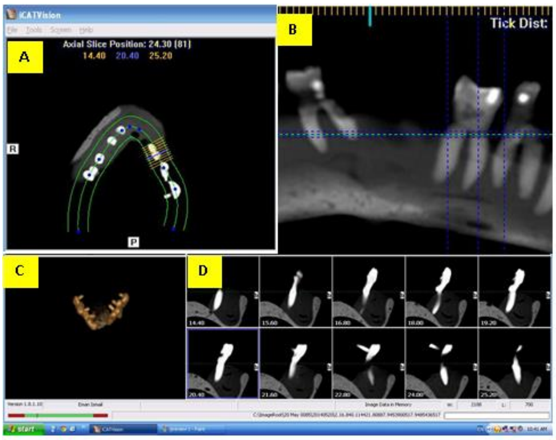


**Fig (5).** *Represents the implant screen of iCAT vision showing: (a) axial cut marked at the area of interest by scrolling through reconstructed panoramic in( b) then automatically the cross-section images will be seen in the same window(D), skull view of the area of interest (C)*

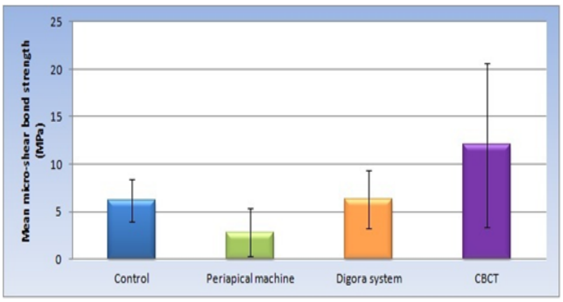


**Fig.** *(6) Descriptive statistics and results of comparison between micro-shear bond strengths of the four tested groups.*

## DISCUSSION

In the present short-term laboratory study, the tooth restoration complex was submitted to different types of imaging radiation systems to evaluate their influence on adhesive bond strength. The results of this study showed a significant detrimental effect of imaging systems on the bond strength to dentin. Our findings [Figure 5] of decreased bond strength after repeated perapical imaging exposure of the composite discs bonded to dentin samples. These findings may be attributed to x-ray-induced alteration of the substrate, as previous studies showed decreased mechanical properties and damage to collagen fibrils after periapical imaging exposure.[4,7,10,14] Moreover, it has been reported that the apatite crystals of dental hard tissues incorporate some sodium, carbonate, and magnesium by entrapment during their formation. When irradiated, these point defects could be mobilized from the surface layer of the crystals, removing the entrapped ions and modifying the structure of the crystals, thus potentially interfering with the adhesion.[15]

Though Our finding revealed that no statistical significance difference between microshear bond strength of control group and digora system, it may be attributed to that digital imaging provides dose reduction of 50%-94% compared with Ekta-speed film. However, in clinical practice the exposure time for the digital radiographic systems generally has been set to 10%-50% of that of E-speed films.[16]

Also it was found that CBCT group showed the statistically significantly highest mean micro-shear bond strength. This finding was explained by Charles R.[17] who mentioned that CT is a powerful and accessible non-destructive technique with which the relationship between occlusional antisensitivity treatments and the internal dentin morphology can be explored. The CT analysis demonstrates unequivocally that computed tomography operating at specific parameters is capable of resolving the porous sub-structure of dentin. Resulting in highly orientated nature of the dentin tubules within the dentin matrix and easily observed after the calcified structure is made semi-transparent.

## CONCLUSION

Repeated periapical irradiation may negatively affect bond strength of dentin to present composite restoration.

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