Impact of radiotherapy and shielding on the efficacy of the self-etch adhesive technique

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Abstract
Context: The exposure to gamma radiation affects the enamel and dentin in teeth restored with composite restoration, but little has been done to protect from the detrimental effect.

Aims: The aim of this in vitro study was to evaluate the effect of gamma radiation, with or without shielding (0.5 mm thickness of lead), in Class V cavities prepared on teeth exposed before and after restoration using the self-etch adhesive technique.

Methods: A total of 75 intact teeth were selected. The samples were divided into five groups: Group I (15 teeth) not exposed to gamma radiation. Group II and III exposed to gamma radiation as per the standardized radiation protocol (2 Gy/day for 5 days/week = 10 Gy/week for 6 weeks = 60 Gy). Group III shielded, using a “0.5 mm thickness of lead” molded into a “C” shaped tube. Standardized Class V cavities were prepared on the buccal surface of all teeth and were restored by composite. Groups IV (not shielded) and V (shielded) were then exposed to standardized radiation protocol. All the samples were evaluated for the assessment of microleakage under stereomicroscope.

Statistical Analysis Used: Statistics were tabulated using the Kruskal–Wallis ANOVA test.

Results: Samples showed a significant difference in dye penetration scores.

Conclusions: The samples restored before being exposed to gamma radiations performed better. Shielding with 0.5 mm of lead has shown increased efficacy of self-etch adhesive system irrespective of the stage of exposure.

Keywords: Class V; composites; gamma rays; self etch; shielding

INTRODUCTION

Almost a million new cases of cancer are diagnosed every year in India alone.[1] Worldwide, head-and-neck cancer (HNC) accounts for more than 830,000 new cases/year with a mortality rate exceeding 430,000.[1] A multidisciplinary approach, i.e., radiation therapy (RT), surgery, chemotherapy, or all combined, is required for an optimal therapeutic strategy and it depends on the site at which it arises.

RT procedure used to treat HNC uses external beam therapy: A method for delivering a beam of high-energy X-rays or proton beams to the location of the tumor, sparing normal tissues. RT has demonstrated significant benefits in local tumor control and patient survival.[2] However, it is challenged by inherent toxicity, notably radiation-induced oral mucositis, xerostomia, candidiasis, dysgeusia, loss of taste, muscular trismus, vascular alterations, and radiation caries.

Under the normal set of circumstances, dental composites are the materials of choice to be used as direct restorations for its better bonding to the tooth and minimal tooth access this article online

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substance loss. The latest generations of bonding agents are principally focused on self-etch adhesive techniques. “Self-etch adhesive technique” does not use etching, rinsing, and drying as different steps. Hence, it makes it less technique sensitive by limiting the errors that can occur with the multi-step system (i.e., over-wetting or overdrying the dental substrate). This technique also lessens the susceptibility of the dental substrate to moisture contamination. Another proposed advantage is decreasing or eliminating postoperative sensitivity. The major problem with composites remains microleakage at the interface between the teeth and the restorative materials.

Gamma rays are pure energy and identical to high-energy X-rays; they penetrate deep into the body, causing detrimental side effects. Shielding materials such as concrete, lead, or steel are required to absorb the extra energy and protect the healthy tissues. In the medical side, individually customized shielding appliances have been manufactured for the patient undergoing treatment with radiotherapy. Considering the medical model, intraoral shielding using lead was used, assuming that it may equally be advantageous in situations where oral tissues need to be exposed.

An in vitro study is designed to use lead as a shield for the teeth to check the efficacy of self-etch adhesive system (Adper Easy One) in Class V cavities prepared on teeth exposed before and after restoration. The efficacy was assessed and statistically analyzed in terms of microleakage.

**METHODS**

Seventy-five intact permanent human premolars with no evidence of restorative or endodontic treatment, without any evidence of cracks, fractures, or developmental anomaly and teeth of patients without any history of radiation exposure were selected. The samples were stored in normal saline till further use.

These samples were randomly divided into five groups (Groups I, II, III, IV, and V) of 15 samples each based on the stage where gamma rays exposure was made. Group I samples (15 teeth) were not exposed to gamma radiation at any stage. Groups II and III were exposed to gamma radiations to a cumulative dose of 60 Gy again in a fractionated manner. Groups IV and V were then exposed to radiation at the time of exposure. The restored teeth were then stored at 37°C for 24 h in distilled water. After storage, the samples were thermocycled at 5°C–55°C for 500 cycles.

All the samples were evaluated for the assessment of microleakage using dye penetration method under stereomicroscope.

**Statistical analysis**

All the data were collected, tabulated, and analyzed by the Kruskal–Wallis ANOVA test.

**OBSERVATIONS AND RESULTS**

**Stereomicroscopic assessment**

The obtained data were analyzed statistically using the following scores.

0 – No penetration
1 – Dye penetration half the distance from the cavosurface margin.

**Table 1: Micro-leakage scores of all the samples assessed under stereomicroscope using dye penetration method**

| Group | Micro-leakage scores | Group | Micro-leakage scores | Group | Micro-leakage scores | Group | Micro-leakage scores |
|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|
| I     | 0                     | II    | 1                     | III   | 2                     | IV    | 3                     |
| II (N) | 0                     | II (B) | 1                     | III (B) | 2                     | IV (A) | 3                     |
| III (N) | 0                     | III (B) | 1                     | IV (B) | 2                     | V (A)  | 4                     |
| IV (N) | 0                     | IV (B) | 1                     | V (B)  | 2                     | V (A)  | 4                     |
| V (N)  | 0                     | V (B)  | 1                     | V (A)  | 4                     |

**Table 2: Kruskal–Wallis ANOVA**

| Group | Mean±SD | Critical value | P     |
|-------|---------|----------------|-------|
| N     | 0.80±0.68 | 20.054         | <0.001*  |
| B     | 2.67±0.49 |                |       |
| (B)   | 1.80±0.68 |                |       |
| A     | 2.07±0.80 |                |       |
| (A)   | 1.00±0.65 |                |       |

*Significant difference, Kruskal–Wallis ANOVA test. SD: Standard deviation
The comparison of mean stereomicroscopic values shows that samples which were shielded, i.e., Group (A) and Group (B) accomplished better results than samples which were not shielded, i.e., Group A and Group B. The Group (A), i.e., samples which were shielded and restored with composite before being radiated showed the best result out of all the groups [Table 1].

Post hoc Bonferroni test was performed to analyze and confirm the significant difference obtained among the result of various groups. All of the group differences were significant.

On the basis of above evaluation of microleakage scores, following inference can be made (from least to most):

Group I, N (unexposed) < Group V, (A) (exposed after restoration and shielded) < Group III, (B) (exposed before restoration and shielded) < Group IV, A (exposed after restoration) < Group II, B (exposed before restoration).

**DISCUSSION**

The samples of Group I, representing clinical situation where the patient does not have to undergo radiotherapy at any given stage, shows a mean microleakage score of 0.80 ± 0.68. These values are remarkably less than those observed in the samples of other groups indicating that radiotherapy applied before or after restoration significantly reduces the efficacy of the bonding agent [Table 2].

In comparison to Group I, the samples of Group II have performed the poorest with mean microleakage value of 2.67 ± 0.49. The exact mechanism because of which bonding performed poorly cannot be explained with certainty, but it seems radiotherapy results in compositional, morphological, and metabolic alterations at the dental substrate level that negatively affect the bonding process.

During and after the course of radiotherapy, adverse changes have been seen in hard and soft tissue because of direct as well as indirect effects of radiation. The physical changes produced by ionizing radiation are mainly recrystallization of mineralized tissue and denaturation of organic structure caused by free radical formation.[6]

It is a known fact that radiation acts on the water leading to free radicals and hydrogen peroxide formation.[7] It has also been reported that irradiated dental tissues might accommodate free radicals within their structure for long periods, which could impair the bonding process.[8]

The accumulation of these free radicals and oxygen species by their reaction with the organic component of dental substrate leads to its denaturation.[9] This protein degradation increases tooth fragility by altering their secondary and tertiary structures too.[10-12] In this dry and friable dental tissue, collagen mesh is not completely infiltrated by the adhesive, leaving behind spots for stress concentration-generating failures. The alterations in intra-and intertubular collagen and metabolic alterations might negatively affect the bonding process.[10]

As dentin supports enamel, a softer dentin tissue becomes less efficient, affecting the bonding ability of enamel too.[10] Therefore, reduction of the mineral–organic interaction between apatite and collagen and production of carbon dioxide results in microcracks in hydroxyapatite mineral which causes roughened tooth surface thereby, interfering with the adhesion of resinous restorative material.[8,12,13]

It has also observed that radiotherapy applied before restoration significantly reduces the bonding of resin to the dental substrate. Moreover, he stated that there was an increase in the occurrence of cohesive failures within the dental substrate.[10]

The samples of Group IV (where radiation exposure was made after restoration) have also performed poor in comparison to Group I but marginally better than that of Group II samples, with mean microleakage value of 2.07 ± 0.80.

Radiation leads to increased hydrolysis and this may have resulted in resin degradation and compromised bonding. As radiation acts on water, one probable reason for self-etch deteriorating its performance can be its more hydrophilic nature. Since the concentration of HEMA (2-hydroxyethyl methacrylate) in the composition of one-step self-etch adhesives is high, it tends to attract water. Furthermore, studies have stated the presence of residual water within the adhesives-dental substrate interface, which can be hardly removed. All of this, along with the ionization of minerals, leads to the formation of permeable membrane and hence the easy movement of water from dentin to restoration.[13] It is also observed that radiations affected the existing resin–dentin interface by disturbing the hybrid layer.

The observed damage to resin bonded composite could be due to debonding, chain scission, brittle fracture, and color alteration in matrix polymers.[13] Other problems could be polymer cracking or fracture, delamination, interphase cracking, and filler dislodgment on irradiation.[10]

The better sealing ability of the self-etch bonding agent in Group IV in comparison to that of Group II may be because the irradiation occurred after the photoactivation. There
were excitations in the previously hybridized structure, but not significant enough to yield alterations in the bonds.\textsuperscript{[12]}

On the other hand, when the irradiation occurred before the photoactivation, excitation points and free radicals were created in the organic matrix of the dental substrate\textsuperscript{[7,16]} and remain sheltered there for extended periods. These highly reactive particles later on interfere with polymerization and subsequently impair the bonding process.\textsuperscript{[10]}

The samples exposed to gamma radiation “Before” were getting exposed to in comparison to its unshielded samples of Group II and Group IV, respectively.

The C-shaped tube made up of 0.5 mm thickness of lead used as a shield in Group III and Group V samples have significantly reduced the severity of side effects of radiotherapy in terms of better adaptation and less microleakage.

Lead works as an excellent shielding material because of its properties; its density, high atomic number, and high level of stability. It is very dense, making it very hard for penetrating radiation to get across– instead the radiation collides with the lead’s atoms, move around them inside the metal and it loses its energy. Hence, lead leads to practically no secondary gamma radiation.\textsuperscript{[17]}

The effect of radiotherapy is found to be dose, material, and substrate-dependent, stating that high radiotherapeutic doses have a detrimental influence on the bonding of resin composite to both dental substrates.\textsuperscript{[16]} As lead shield must have reduced the dose of radiation the samples were getting exposed to in comparison to its unshielded counterparts.

**CONCLUSIONS**

From the results, it may be hypothesized that:

1. Microleakage to varying degrees has been detected in all the samples representing three different clinical situations

2. Stereomicroscopy has revealed tooth restoration adaptation with both gap-free and gap-containing regions of different measurements in all the samples

3. Under normal circumstances, with no exposure at any stage, self-etch performed significantly best in terms least microleakage

4. The therapeutic dosage of radiotherapy (60 Gy) at any stage has a significant detrimental effect on the efficacy of self-etch adhesive system

5. The samples exposed to gamma radiation “Before” cavity preparation has performed worse than teeth exposed “After” cavity preparation and restoration in terms of more microleakage and wider gaps

6. “Shielding with 0.5 mm of Lead” has shown increased efficacy of self-etch adhesive system irrespective of the stage of exposure

This study suggests, for improved clinical services, restorations with self-etch bonding technique should preferably be carried out before the time frame of radiotherapy. This study also advocates the “Shielding” of teeth at the time of exposure over “No Shielding.” Postirradiation lesions should be restored promptly and regular follow-up is must to observe any failure.

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**Conflicts of interest**

There are no conflicts of interest.

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