Comparative Clinical Evaluation of Composite Restoration Bonded with 5th and 7th Generation Bonding Agent prepared with Er: YAG Laser – In Vivo Study

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Abstract

Aim: To clinically evaluate and compare cavity preparation with Erbium:Yttrium Aluminum Garnet (Er:YAG) laser bonded with 5th and 7th generation bonded agent restoration with composite resin at 3 months, 6 months and 12 months.

Materials and Methods: 40 patients with class I cavity preparation were bonded with 5th generation bonding agent formed group 1 and 40 patients with class I cavity preparation were bonded with 7th generation bonding agent formed group 2. Patients included had primary proximal carious lesions in posterior teeth 2.21 and 2.22 according to G.J. Mount classification. Cavity preparation was done using Er:YAG laser. Incremental technique of no more than 2mm for inserting composites was used. Evaluation was done using Ryge’s criteria.

Results: No significant difference was observed between clinical performances of the two materials at 3 months. (p>0.05) At 6 months, statistically significant difference was seen with marginal adaptation, secondary caries and post-operative sensitivity. (p<0.05) At 12 months, the post-operative sensitivity was seen to be more with 5th generation bonding agent than the 7th generation.

Conclusion: The composite resin restorations with 7th generation bonding agents showed a lesser degree post-operative sensitivity and secondary caries, as compared to those with 5th generation bonding agents.

Keywords: ER: YAG laser, G.J. Mount classification, composite resin, bonding agent.

Introduction

Dental decay is a highly prevalent concern in India. Several studies have found that being afraid of the dentist is a major cause of dental anxiety, particularly among children and adults. The old concept of “extension for prevention” is changed to “prevention of extension”. Hard tissue laser developed in 1990’s, came to dental market place in 1997. Hard tissue laser can decrease vibration, drill sound and somediscomfort feared by patient alongwiththe fear of high speed hand-pieces which is commendable. Additionally, these lasers could be used with lesser amount of local anaesthetic for several procedures, which is another aspect that makes hard tissue lasers very appealing for needle-phobic patients. Er:YAG laser wavelength is 2.94μm, easily absorbable in hydroxyapatite as well as water and has numerous applications in dental hard tissues. Earlier studies have proven the efficiency and applicability of Er:YAG laser on removal of caries, enamel and dentin etching and preparation of cavity. Contemporary adhesives are applied using two
techniques, ‘etch and rinse' or ‘self-etch'. Studies demonstrate successful as well as reasonably long-lasting restorative methods exist using etch and rinse technology. In spite of limited clinical trials examining their efficacy, self-etch adhesives nonetheless possessed a benefit of absence of intermediate mouthrinse which makes them more user-friendly and less technique-sensitive. Among the most common ones, one- and two-step adhesives are graded as ‘mild' or ‘strong' self-etch adhesives. Particular care must be taken to simulate the clinical conditions present in vivo. In vitro experiments cannot adequately model the fluid flow through dentinal tubules, surface-tension, and functional stresses induced in chewing.\[^6\] Hence, this study is taken up to compare and clinically evaluate cavity preparation with ER: YAG laser bonded with 5th and 7th generation bonded agent restoration with composites.

**Materials and Methods**

A written consent was obtained from patients who agreed for treatment, can be available for follow-ups after the entire treatment modality was explained to each participant. Patients with good oral hygiene were selected according to OHI-Sindex. A single operator performed the restorative procedure on the 80 patients that were recruited for the study. 40 patients with class Icavity preparation were bonded with 5th generation bonding agent formed group 1 and 40 Patients with class I cavity preparation were bonded with 7th generation bondingagent formed group 2. Patients included had primary proximal carious lesions in posterior teeth 2.1 and 2.2 according to G.J. Mount classification. They were excluded if they had Frank occlusal cavitation, hypoplasia, severe attrition or traumatic occlusion. Carious lesions which were classified into 1.1 or 1.2 according to G.J. Mount and Hume classification of caries were taken up.

**Bonding Procedure**

Rubber dam, cotton rolls and saliva ejector were employed to split the patient’s operating field. Er:YAG laser was employed for preparing the cavity. Total-etch technique was implemented with single bond universal for 3M Z-350. Enamel and cavosurface margins were then coated with a primer and bonding agent followed by the insertion of resin composite not more than 2mm using an incremental technique. After the restoration, finishing was performed with fine diamond and multifluted carbide burs. Finally, aluminium oxide discs, coarse to fine were used for performing polishing to secure a smooth surface. Assessment was made using Ryge’s criteria.

**Morphological Analysis**

Scanning electron microscopy of enamel and dentin irradiated by Er: YAG laser showed that enamel had a pattern of micro-retention and dentin showed no smear layer formation with opened dentinal tubules.\[^5\] Two independent assessors assessed the restorations clinically at the time of restoration with use of tactile and visual method; the same was done at 3, 6 and 12 month intervals.

**Statistical Analysis**

Data analysis was done using Statistical Package for Social Sciences (SPSS) for Windows 26.0 (SPSS, Inc. Chicago, Illinois). Confidence intervals were set at 95%, and a p-value ≤ of 0.05 was considered as statistically significant. Fleiss' kappa test was applied to assess reliability of agreement between two assessors. Chi-square test was applied to test association between RYGE’S criteria and composite restoration (Z-350) bonded with 5th generation and 7th generation bonding agents.

**Results**

The mean of Fleiss kappa values was 0.85 which was considered as an excellent agreement between the two examiners and clinical parameters were reliable at 3, 6 and 12 months. No significant difference was seen between clinical performances of the two materials at 3 months. (p>0.05) At 6 months, statistically significant difference was seen with marginal adaptation, secondary caries and post-operative sensitivity. (p<0.05) At 12 months, the post-operative sensitivity was seen to be more with 5th generation bonding agent than the 7th generation.
Discussion

The Er:YAG laser is secure and works well as a treatment for the dentin surface as it removes smear layer like acid etching, opens dentinal tubules and creates a microscopic rough surface with micromechanical retention pattern which is deemed ideal for adhesion.\(^7,8\) Thus, in our study Er: YAG laser was employed for preparing the cavity as it offered patient some comfort by eliminating heat, pressure, sound and vibration produced by drilling.\(^9\)

The pulp is quite sensitive to heat because the rigid pulp cavity does not allow tooth blood vessels to enlarge significantly for heat removal. At temperatures higher than 43 o C, irreversible damage to the pulp occurs. The hyperaemic reaction can be associated with pain perceived by patient, during drilling. In case of Er: YAG laser no such hyperaemia was observed.\(^10\)

Decalcification occurs when acid etchant is applied to enamel and dentin, in the top layer of which causes the loss of minerals. When a resin adhesive is added to a fractured tooth or a tooth that has not retained any mineral content, the 'micro-retained' material helps reconstruct the mineral structure and thus 're-fills' a notch that the tooth had been missing. John Gwinnett\(^11\) first evaluated the adhesive enamel interface describing an acid-resistance layer which was the first true “hybrid layer”.

In this study, isolation has been done with the help of rubber dam during each restoration. It was concluded in a study\(^12\) that for 10-year clinical period a composite restored in a posterior tooth under isolation with cotton rolls and aspiration, was not significantly different from the restorations placed isolation with rubber dam.\(^13\) But for easy usage and better standardisation of the procedure rubber dam has been used in this study to keep the operative area isolated from moisture, saliva, blood and other contaminants that may affect the overall performance of the composite restoration in the long term.

The resin composite was inserted not more than 2mm using an incremental technique to secure good quality of the margins. This will prevent distortion of cavity wall (thus securing adhesion to dentin), ensuring the resin-based composite undergoes complete polymerization.\(^14\) There are many incremental designs which can be used during restoration of a class I lesion. In this study we have used the horizontal incremental design technique to avoid polymerization shrinkage and reduce the C factor as much as possible for better results.\(^15\)

In the present day, with the latest generation of LED units with 1200 mW/cm \(^2\), curing time of 2 mm thick increments of composite obtained durable results and can be reduced to 20 seconds. Curing depth depends on the distance of resin composite to light source, but only decisive when exceeding 6 mm.\(^16-18\) In this study, these guidelines have been followed to curer resin-based composites in both the groups. The finishing and polishing of the restorations were done with the help of carbide burs (S.S. White) and polishing discs and strips (3M Sof-lex). The original Sof-Lex finishing and polishing discs are made using urethane coated paper making the discs flexible.

Evaluation of the composite restoration quality was done using a system of clinical parameters developed by Gunnar Ryge known as the United States Public Health Services (USPHS) criteria or Ryge criteria or Direct evaluation criteria. Existing literature is mostly based on this system on posterior composite restoration performance. Restorations were evaluated independently by two examiners and then compared their scoring. In case of any discrepancies between the two examiners, a third evaluation is done together determining the score by consensus. Thus, this evaluation criteria is based on an operational approach to quality assessment. Call signs are used to delineate the score for each parameter. Alfa (A) indicate satisfactory—meets all standards, Bravo (B) indicate satisfactory— but needs observation at next visit, Charlie (C) indicate not satisfactory- needs replacement for prevention and Delta (D) indicate not satisfactory- needs replacement immediately.\(^19\)

There were three examiners that evaluated the restorations over the period of 12 months. But before starting with our first evaluation of three months it was necessary to train the examiners and make them understand the rating system that we had adopted. This would eliminate the probable bias in the study which would occur if the examiners were not pre-trained in rating the restorations in accordance correctly.\(^17\) A statistical analysis was done to check inter examiner agreement to the ratings given by them. In this study we have used the Fleiss kappa test. The measure calculates degree of agreement classified over which would be expected by chance and is scored as a number.
between 0 and 1. There is no general agreement on the measure of significance, although guidelines have been given.

The mean of the Fleiss Kappa values comes up to 0.85 which is considered as there is excellent agreement between the three examiners and that their readings are reliable. The results of the present study demonstrated no statistically significant differences between these two materials when evaluated for 3 months but some of the parameters had shown statistically significant difference during the six month and the twelve-month evaluation. The colour stability in both the study groups did not show any differences statistically during the entire study period. The colour stability can be attributed to the quality of the composite material and not to the bonding agent. Therefore, since the same nano filled composite was used for both groups, there was no difference. Nanofilled composites show a greater stability of optical properties, as compared to other composites.[20]

Cavosurface discolouration was not significantly different during the three months, six months and twelve months recall and evaluation. However, at 6 and 12 months recall, restorations with 7th generation bonding agent were having less cavosurface discolouration than restorations with 5th generation bonding agent, even though the difference was not significant. In their 4 year clinical study, Geurtsen and Scholer[21] stated that marginal discoloration to be the most prominent issue in posterior composite restorations. Difficulty in distinguishing secondary caries from marginal staining commonly leads to replacing the restoration generating overtreatment. Polymerization shrinkage is one of the reasons for cavosurface marginal discoloration.[22]

To conclude, in current clinical practise, benefits of posterior composite therapy may be have significantly due to (1) the discoloration of posterior structures which look like and are the same as discoloration of the disc margin (cavosurface marginal discolouration), and (2) the simultaneous appearance of those features..[23] No significant difference in this study proves that the bonding agent does not greatly affect the polymerization shrinkage.

Marginal adaptation did not show any significant statistical difference for 3 months analysis but the difference was significant for 6 and 12 months analysis. Resisting the polymerization forces during the bonding process is an important part of the cohesive properties of an adhesive and keeps the seal between the tooth structure and the composite consistent throughout the length and breadth of the composite. It is possible to create objects in the oral setting that avoid disintegration and crazing, but they're not really sustainable. Although the increase in width is a step in the right direction, the ability to close the margins of reconstruction would require the dentin collagen network to be able to withstand greater forces, such as those caused by an increase in the force required to seal it. If particles cannot penetrate through the denuded collagen network, it will soon be promoted for open pathways. These open pathways can allow for nanoleakage under the restoration. If the nanoleakage is more, the dentin bond may degrade over time.

Marginal adaptation discrepancy is a later stage of the cavosurface marginal discolouration and thus when more discolouration was observed in 5th Generation bonding agent restorations during the 12 months recall, marginal adaptation seems to have followed suit. The reason for this could be that the walls of the cavity were greatly demineralized after preparation with Er: YAG LASER, and then etching with 37% phosphoric acid. This demineralised enamel demonstrated poorer marginal adaptation. Besides, a causative factor for the increased demineralization could also be low pH. 37% phosphoric acid has a low pH of 1 as compared to 7th Generation bonding agent, which has a pH of 2.7.

Anatomical form did not show much difference during the 3 months and the 6 months recall but showed some difference during the 12 months recall. The change in anatomical form can be attributed to wear of composites. The wear of composites is related to the filler particle size, shape and amount.[24,25] The slight difference, seen in anatomical form at 12 months, could be attributed to the poor marginal adaptation and presence of secondary caries exhibited by the restorations using 5th Generation bonding agent.

The surface texture in both the study groups did not show any differences statistically during the entire period of study. This can be attributed to the superior properties of the nanofilled composite material used in this study; this can be because this material presented the lowest surface roughness.
when finishing and polishingsystems were used.[26] At 6 and 12months interval, the difference in the incidence of secondary caries, in restorations with 5th and 7thgeneration bonding agents was statistically significant. Therestorations with 5th Generation bonding agents showed higher prevalence of secondary caries. This could be because applying phosphoric acid for etching theenamel made the surface more receptive to caries as demineralization of the superficial layer takes place. The physiochemical changes by laser etching decreased acid attackas well as caries risk.[9] Hence the double etching caused by Er: YAG LASER and phosphoric acid may have led to a raised prevalence of secondary caries compared to those restorations where Er: YAG LASER etching was employed alone with a 7th Generation bonding agent.

Post-operative sensitivity occurred in more number of restorations where 5th Generation bonding agent was applied, and the difference was highly significant. Most acids are hypertonic and displace pulp fluid which causes movement of the odontoblasts in relation to pulp response. Acid solutions can denature the collagen fibres raising dentin permeability and humidity which could encourage chemical aggression by the adhesive system and bacterial infiltration and for all these reasons, damage the bond causing pain.[27] Moreover, the demineralised surface formed by the acid makes the enamel more susceptible to leakage and secondary caries, thereby leading to post-operative sensitivity. A study demonstrated that 7th Generation bonding agent was better at sealing both coronal and apical margins when compared to other dentin bonding agents, and also showed significantly less leakage than others. Due to this reduced leakage, the chances of post-operative sensitivity also get reduced. Thus, it has been interesting to note that the overall clinical performance of 7th generation bonding agents has been better than 5th generation bonding agent when Er: YAG LASER was used to prepare the cavity.

**Conclusion**

In conclusion, composite resin restorations with 7th generation bonding agents showed a lesser degree post-operative sensitivity and secondary caries, as compared to those with 5th generation bonding agents. Further clinical evaluation of a longer period of time is necessary to come to a better conclusion regarding the adhesives, with laser cavity preparation.

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**Conflicts of interest:** Nil

**References**


8. Davari A, Sadeghi M, Bakhshi H. Shear Bond Strength of an Etch-and-rinse Adhesive to

Tables

Table 1: Association between Composite restoration for Marginal Adaption (occlusal) and RYGE’s Criteria

<table>
<thead>
<tr>
<th>RYGE’s Criteria</th>
<th>Composite restoration (Z-350) Marginal Adaption (occlusal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5th generation bonding agent (n=40)</td>
</tr>
<tr>
<td>After 3</td>
<td>After 6</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>5th generation bonding agent (n=40)</td>
<td></td>
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<tr>
<td>7th generation bonding agent (n=40)</td>
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</tr>
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### Table 2: Association between Composite restoration for Secondary Caries and RYGE’s Criteria

<table>
<thead>
<tr>
<th>RYGE’s Criteria</th>
<th>Composite restoration (Z-350)</th>
<th>Secondary Caries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5th generation bonding agent</td>
<td>7th generation bonding agent</td>
</tr>
<tr>
<td></td>
<td>(n=40)</td>
<td>(n=40)</td>
</tr>
<tr>
<td>After 3 months restoration (n=37)</td>
<td>After 6 months restoration (n=35)</td>
<td>After 12 months restoration (n=35)</td>
</tr>
<tr>
<td>A</td>
<td>34 (91.89%)</td>
<td>21 (60%)</td>
</tr>
<tr>
<td>B</td>
<td>3 (81.09%)</td>
<td>14 (40%)</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

Value of $\chi^2 = 13.159$, $p<0.05$

### Table 3: Association between Composite restoration for PostOperative Sensitivity and RYGE’s Criteria

<table>
<thead>
<tr>
<th>RYGE’s Criteria</th>
<th>Composite restoration (Z-350)</th>
<th>Post Operative Sensitivity</th>
</tr>
</thead>
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<tr>
<td></td>
<td>5th generation bonding agent</td>
<td>7th generation bonding agent</td>
</tr>
<tr>
<td></td>
<td>(n=40)</td>
<td>(n=40)</td>
</tr>
<tr>
<td>After 3 months restoration (n=37)</td>
<td>After 6 months restoration (n=35)</td>
<td>After 12 months restoration (n=35)</td>
</tr>
<tr>
<td>A</td>
<td>31(83.78%)</td>
<td>17(48.57%)</td>
</tr>
<tr>
<td>B</td>
<td>6 (16.22%)</td>
<td>18 (51.43%)</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
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Value of $\chi^2 = 13.149$, $p<0.05$