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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. 2.1 and 2.2 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".[1]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.[2]Er:YAG laser wavelength is 2.94μm, easily absorbable in hydroxyapatite as well as water and has numerous applications in dental hard tissues.[3]Earlier studies have proven the efficiency and applicability of Er:YAG laser on removal of caries, enamel and dentin etching and preparation of cavity.[4]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 40Patients with class I cavity preparation were bonded with 7th generation bondingagent formed group 2.Patients included had primary proximal carious lesions in posterior teeth2. 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 andHume 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 cavo surface 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 ofrestoration with use of tactile and visual method; the same was done at 3, 6 and 12month 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 $\leq$ 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 5^{th} generation and 7^{th} generation bonding agents.

Results

The mean of Fleiss kappa values was 0.85which 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 wellas a treatment for the dentin surfaceas it removes smear layer like acidetching, opens dentinal tubules and createsa microscopic rough surface with amicromechanical 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 eliminatingheat, pressure,soundand vibration produced by drilling.[9]

The pulp is quite sensitive to heat because the rigid pulp cavity does not allowtooth blood vessels to enlarge significantly for heat removal. At temperatures higher than43 o -49 o C, irreversible damage to the pulp occurs. The hyperaemic reaction can beassociated with pain perceived by patient, during drilling. In case of Er: YAG laser nosuch 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 adhesiveenamel interfacedescribing 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 eachrestoration. 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 therestorations placed isolation with rubber dam.[13] But for easy usage and betterstandardisation of the procedure rubber dam has been used in this study to keep theoperative area isolated form moisture, saliva, blood and other contaminants that mayaffect 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 designswhich can be used during restoration of a class I lesion. In this study we have used thehorizontal incremental design technique to avoid polymerization shrinkage and reducethe 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 thisstudy, these guidelines have been followedto cureresin-based composites inboth 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 andpolishing discs are made using urethane coated paper making the discsflexible.

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 systemon 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 needsobservation at next visit, Charlie (C) indicate not satisfactory- needs replacement forprevention and Delta (D) indicate not satisfactory-needs replacement immediately.[19]There were three examiners that evaluated the restorations over the period of 12months. But before starting with our first evaluation of three months it was necessary totrain 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 examinerswere not pre-trained in rating the restorations in accordance correctly.[17]A statistical analysis was done to check inter examiner agreement to theratings 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 chanceand is scored as a number

between 0 and 1. There is no general agreement on themeasure of significance, although guidelines have been given.

The mean of the Fleiss Kappa values comes up to 0.85 which is considered asthere is excellent agreement between the three examiners and that their readings arereliable.The results of the present study demonstrated no statistically significant differences betweenthese two materials when evaluated for3months but some of the parameters had shownstatistically significant difference during the six month and the twelve-month evaluation.The colour stability in both the study groups did not show any differencesstatistically during the entire study period. The colour stability can be attributed tothe quality of the composite material and not to the bonding agent. Therefore, since thesame nano filled composite was used for both groups, there was no difference. Nanofilledcomposites show a greater stability of optical properties, as compared to othercomposites.[20]

Cavosurface discolouration was not significantly different during the threemonths, six months and twelve months recall and evaluation. However, at 6 and 12month recall, restorations with 7th generation bonding agent were having lessercavosurface discolouration than restorations with 5th generation bonding agent, eventhough the difference was not significant. In their 4 year clinical study, Geurtsen andScholer[21]stated that marginal discolorationto be the most prominent issue in posterior composite restorations. Difficulty in distinguishing secondary caries from marginalstaining commonly leads to replacing the restoration generating overtreatment.Polymerization shrinkage is one of the reasons for cavosurface marginal discolouration.[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 discoloration), and (2) the simultaneous appearance of those features..[23]No significant difference in this study proves that the bonding agent does not greatly affectthe polymerization shrinkage.

Marginal adaptation did not show any significant statistical difference for 3months analysis but the difference was significant for 6 and 12month 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 therestoration. If the nanoleakage is more, the dentin bond may degradeover time.

Marginal adaptation discrepancy is a later stage of the cavosurface marginaldiscolouration and thus when more discolouration was observed in 5th Generationbonding agent restorations during the 12 months recall, marginal adaptation seems tohave followed suit. The reason for this could be that the walls of the cavity were greatlydemineralized after preparation with Er: YAG LASER, and then etching with37% phosphoric acid. This demineralised enamel demonstrated poorer marginal adaptation.Besides, a causative factor for the increased demineralizationcould also be low pH.37% phosphoric acid has a low pH of 1 as compared to 7th Generationbonding agent, which has a pH of 2.7.

Anatomical form did not show much difference during the 3 months and the 6months recall but showed some difference during the 12 months recall. The change in anatomical form can be attributed to wear of composites. Thewear 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 thepoor marginal adaptation and presence of secondary caries exhibited by the restorationsusing 5th Generation bonding agent.

The surface texture in both the study groups did not show any differencesstatistically during the entire period of study. This can be attributed to the superiorproperties of the nanofilled composite material used in this study; this can be becausethis material presented the lowest surface roughness

when finishing and polishingsystems were used.[26]At 6 and 12months interval,the difference in theincidence of secondary caries, in restorations with 5th and 7thgeneration bonding agents was statistically significant. Therestorations with 5th Generation bonding agents showed higher prevalence ofsecondary caries. This could be because applying phosphoric acid for etching theenamel made the surface more receptive to caries as demineralization of thesuperficial 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 andphosphoric acid may have led to a raised prevalence of secondary cariescompared to those restorations where Er: YAG LASER etching was employed alonewith a 7th Generation bonding agent.

Post-operative sensitivity occurred in more number of restorations where 5thGeneration 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 surfaceformed by the acid makes the enamel moresusceptible to leakage and secondary caries, thereby leading to post-operative sensitivity.A study demonstrated that 7th Generation bonding agent was better at sealingboth coronal and apical margins when compared to otherdentin bonding agents, and also showed significantly less leakage than others. Dueto 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 7thgeneration bonding agents has been better than 5th generation bonding agent whenEr:YAG LASER was used to prepare the cavity.

Conclusion

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

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Conflicts of interest : Nil

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Tables

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

RYGE's Criteria	**Composite restoration (Z-350) Marginal Adaption** (occlusal)					
	5th generation bonding agent (n=40)			**7th generation bonding agent (n=40)**		
	After 3	**After 6**	**After 12**	**After 3**	**After 6**	**After 12**

	months restoration (n=37)	months restoration (n=35)	months restoration (n=35)	months restoration (n=37)	months restoration (n=35)	months restoration (n=35)
A	33 (89.19%)	23 (65.71%)	14 (40%)	35 (94.59%)	34 (97.14%)	30 (85.71%)
B	4 (10.81%)	12 (34.29%)	19 (54.29%)	2 (5.41%)	4 (2.86%)	6 (17.14%)
C	0	0	3 (8.57%)	0	0	0

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

Table 2: Association between Composite restoration for Secondary Caries and RYGE's Criteria

RYGE's Criteria	Composite restoration (Z-350) Secondary Caries					
	5th generation bonding agent (n=40)			7th generation bonding agent (n=40)		
	After 3 months restoration (n=37)	After 6 months restoration (n=35)	After 12 months restoration (n=35)	After 3 months restoration (n=37)	After 6 months restoration (n=35)	After 12 months restoration (n=35)
A	34 (91.89%)	21 (60%)	16 (45.71%)	37 (100%)	33 (94.29%)	33 (94.28%)
B	3 (81.09%)	14 (40%)	20 (51.29%)	0	2 (5.71%)	3 (5.71%)
C	0	0	0	0	0	0

Value of $\chi^2 = 16.355$, $p<0.05$

Table 3: Association between Composite restoration forPostOperative Sensitivity and RYGE's Criteria

RYGE's Criteria	Composite restoration (Z-350) Post Operative Sensitivity					
	5th generation bonding agent (n=40)			7th generation bonding agent (n=40)		
	After 3 months restoration (n=37)	After 6 months restoration (n=35)	After 12 months restoration (n=35)	After 3 months restoration (n=37)	After 6 months restoration (n=35)	After 12 months restoration (n=35)
A	31(83.78%)	17(48.57%)	14 (40%)	37 (100%)	32(91.42%)	30 (85.71%)
B	6 (16.22%)	18 (51.43%)	22 (62.86%)	0	3(8.58%)	6 (17.15%)
C	0	0	0	0	0	0

Value of $\chi^2 = 13.149$, $p<0.05$