EVALUATION OF MICROTENSILE BOND STRENGTH OF SELF ETCH ADHESIVE TO CARIOUS TEETH USING TWO DIFFERENT CARIES REMOVAL TECHNIQUE - AN IN VITRO STUDY

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ABSTRACT

Background & Objective: - Various methods of caries excavation like dental hand pieces/bur, sono abrasion, air abrasion, ultra sonication, caries dissolving gels, lasers, enzymatic caries dissolving agents and ozone therapy are now available for clinicians. Micro tensile bond strength is one of the method used to assess the strength of resin and dentin interface complex. The present study aimed to evaluate microtensile bond strength of nanocomposite to dentin and morphological changes in dentin following caries removal using mechanical and LASER.

Materials and Method: - Selected specimens (30 carious molar teeth) were grouped randomly into two experimental group, (n=15) namely Group I rotary preparation by diamond bur (mechanical), and Group II preparation by Er:YAG LASER (laser) The surface were then bonded with a two step self etch adhesive and cured with a light cure unit. The bonded surfaces were restored using nanocomposite (filtek z 250). Specimens were sectioned into 1 mm square samples and was subjected for bond strength measurement. The maximum microtensile bond strength was noted at the time of fracture (de-bonding) of the restorative material. Results collected were subjected to ANOVA test, Tukey's multiple post hoc to evaluate statistically..

Result: - The highest bond strength was observed for mechanical excavation than laser group and the difference was statistically significant.

Conclusion: - Mechanical caries excavation method remains superior to recent advances like lasers.

Key Words: - Caries Removal, Er:Yag LASER, LASER, Micro Strength.

Introduction

Dental caries is one of the most common diseases found almost all around the world producing pain and discomfort. Conventional cavity preparation and caries removal are based on Black's principle of extension for prevention which requires removal of healthy tooth structure there by leading to loss of tissue. In recent years, conservative cavity preparation has gained popularity with the introduction of adhesive resin bonding systems. Various methods of caries removal like using dental hand pieces/bur, sono abrasion, air abrasion, air polishing, ultrasonications, caries dissolving gels, lasers, enzymatic caries dissolving agents and ozone therapy have been introduced. Minimal invasive dentistry helps in the most conservative preparation of cavities by slight extension by beveling the cavity margins. The superficial necrotic zone of caries infected dentin harbor the core bacterial mass and this should be excavated leaving only the residual caries affected dentin which helps in good peripheral seal. However, the extent to which carious dentin should be removed in order to achieve a mechanically and biologically successful restoration is still a matter of debate.[1]

In particular, no definite diagnostic tool is available today to clinically define the caries-removal endpoint, enabling complete removal of infected tissue without overextending cavity preparation. In addition, the different techniques presently available for caries removal/cavity preparation produce residual dentin substrates of different natures and thus different receptiveness for adhesion.[2]

Currently lasers are considered suitable for caries removal and tooth preparation. The energy levels of this laser is adjusted so that there is an optimal amount of light absorbed enabling the removal of only the carious dentin leaving behind the sound dentin intact. The basic mechanism of bonding to enamel and dentine is an exchange process involving replacement of minerals removed by the resin monomers which becomes micromechanically interlocked in the created porosities. Bonding to dentine is challenging due to various reasons like presence of smear layer, dentinal fluid, considerable amount of organic material compared to enamel and its close proximity to pulp. A number of new adhesive systems have been developed in an attempt to reduce the steps and simplify clinical bonding procedures. Self-etching primers eliminate the separate acid-etching and rinsing steps. Recently, all-in-one adhesive systems or self-etching adhesives which combine the etching, priming and bonding procedures into one solution and one step have been introduced. Development of microtensile test method determines the bond strength of several bonding systems to caries affected dentin.[3]

To our best knowledge there are no studies in literature evaluating the microtensile bond strength of nano-composites to dentin, following LASER & conventional mechanical caries excavation. Hence, the aim of this in-vitro study was to evaluate the microtensile bond strength values of an adhesive bonded to the residual dentin after two different contemporary caries excavation method namely mechanical (bur) and laser ablation (Er;YAG

LASER) and to assess the failure mode after microtensile testing.

Materials and Method

The study was conducted in Department of Conservative Dentistry and Endodontics, M.R.Ambedkar Dental College, Bangalore and the Ethical clearance for the study was obtained from the ethical committee and review board of the institution.

Data collection

Thirty molar teeth extracted due to caries were collected from Department of Oral and Maxillofacial Surgery, M.R. Ambedkar Dental College, Bangalore. (Figure 1)

Figure 1: - Thirty extracted molar.

Teeth with fluorosis or hypo calcification, grossly decayed tooth, teeth with defective restoration and facets, teeth with cracked structure, teeth with presence of any wasting diseases and teeth extracted from patients who had periodontal disease were excluded from the study.

Study Design

The teeth selected for the study were cleaned thoroughly to remove debris and stored in distilled water. Thirty extracted molar teeth was randomly divided into two groups (n=15) based on a coin toss method. Group I: Round tungsten carbide bur group (air turbine NSK) & Group II: ER-YAG LASER.

Group I: Teeth were ground with a diamond disc perpendicular to the long axis of the teeth to expose the superficial dentin with a surface area of about 5 mm^2 without pulp exposure. The samples were polished with 400- and 600- grit silicon carbide papers under running water to create a flat surface and a homogenous smear layer. Occlusal portion of tooth was removed till dentin perpendicular to the long axis of the tooth to expose the dentin with a central zone of caries infected dentin.

Group II: The caries was removed using no 2 round bur with high speed handpiece and Er:YAG LASER till the firmness of dentin was felt. Dentin was irradiated with a pulsed Er:YAG laser (fotona) at a wavelength of 2.94 mm, a pulse duration of 250-500 micro seconds under water cooling. The output power and repetition rate of this equipment was 350 mj 12 Hz. samples were irradiated by hand scanning the surface once in each direction. The energy density used was 4.20 W. (Figure 2 & 3)

Figure 2: - Er:Yag Laser used for caries removal

Figure 3: - Cavity preparation with Er:YAG LASER.

Restorative Procedure

Following dentinal caries removal with respective methods, one step self-etching adhesive was used on all the dentin surfaces according manufacturer's instructions. A hybrid nano-composite restorative material Filtek Z 250 XT composite was placed over the bonded surfaces incrementally (4 mm total thickness) to allow for gripping during the tensile testing. Increment thickness was limited to 2 mm, and curing was accomplished for 40 sec per increment.

Microtensile Bond Strength Testing

For microtensile bond strength evaluation, all restored teeth were stored in distilled water at 37°C for 24 hours. The restored teeth were sectioned perpendicular to the bonded interface in a high speed handpiece to produce a cross sectional surface area of 1.0 mm^2. The specimens were glued on a jig placed on a tensile tester machine and subjected to tensile force at a crosshead speed of 1 mm per minute. (Figure 4 - 7)

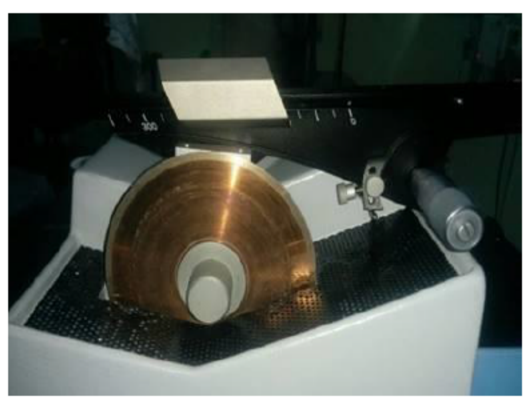

Figure 4: - Slow speed diamond saw

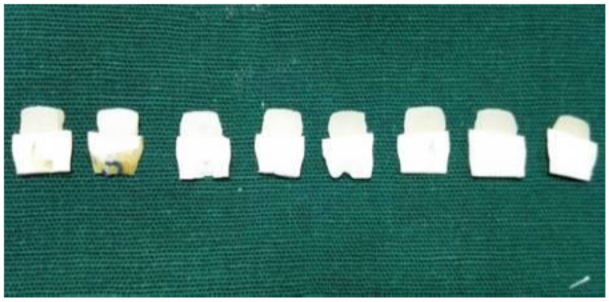

Figure 5: - Beams obtained after sectioning of samples

Figure 6: - Custom made stainless steel testing forcep

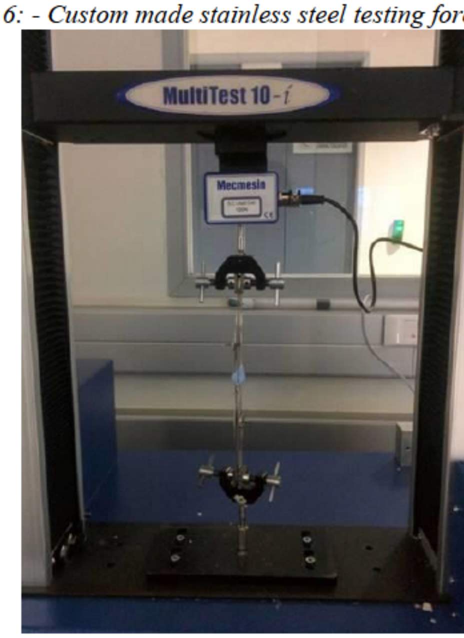

Figure 7: - Beam held in jig for tensile testing in universal testing machine

Statistical Analysis

The results obtained from micro-tensile bond strength testing were subjected to TWO WAY ANOVA and Tukey-HSD test. The mean and standard deviation values were calculated and expressed as MPas.

Results

Caries removal effectiveness and minimal invasiveness potential of conventional mechanical (bur) excavation was compared with laser. It was found that the surface remaining after mechanical bur excavation and bonding with mild self-etched adhesive seem to be more compatible allowing deeper penetration of the adhesive, resulting in a thick homogeneous hybrid layer. The highest bond strength was observed for mechanical excavation than laser group and the difference was statistically significant. (Table 1)

Groups	Mean-MTS*	S.D.#	Range	Mini mum	Maxi mum
Group-I (Bur)	6.44	1.66	4.88	4.28	9.16
Group-II (Laser)	3.29	1.07	3.78	1.14	4.92

*MTS: micro-tensile strength, #SD: Standard deviation,

Table 1: - Micro tensile bond strength between mechanical excavation (bur) and laser (Er:YAG)

Discussion

Minimal invasive dentistry has gained popularity with the development of new adhesive systems and technological improvements in tooth preparation.[1] This helps to have a controlled removal of infected and softened dentin, preserving the healthy and hard tissues and perform with a minimal discomfort to the patient.[4] Conventional cavity preparation and caries removal are based on Black's principle of extension for prevention. This enables us to remove healthy tooth structure which leads to excessive tooth loss.[1] It is now recognized that demineralised but noncavitated enamel and dentine can be healed.[5] Carious dentin consists of two different layers having different ultramicroscopic and chemical structure. The outer carious dentin is irrereversibly denatured, infected, not remineralizable and must be removed. The inner carious dentin is reversibly denatured, not infected, remineralizable and must be preserved.[6,7] Defining the actual end point of caries excavation is the start point of restoration.[8] Kidd EA suggested removing carious dentin to the level where it is firm.[9] Rotary instruments removes the carious dentin quite fast and efficiently that results in the unnecessary removal of the healthy or even affected dentin that shows the ability for remineralization. This causes more discomfort and pain to the patient.[10] Hence there is an interest to develop methods which is more patient friendly and caries removal/excavation very conservatively providing less thermal changes, less vibration and removal of infected dentin only.

Various technique for this are lasers, chemicomechanical, air abrasion, etc. Many of these techniques tend to over or under prepare or also do not completely remove the smear layer.[11] Laser ablation offers an attractive alternative to conventional caries removal. Various lasers currently used are ER:YAG , Nd:YAG, CO_2, excimer lasers, argon lasers, Er:Cr:YSGG.[12] Among the erbium lasers, Er:YAG and Er:Cr:YSGG are the two types used currently. both have a similar wavelength 2.78 mm Er:Cr:YSGG and 2.944 mm Er:YAG. The Er:YAG is absorbed more by hydroxyapatite than Er:Cr:YSGG. This coincides with the absorption peak of water and is well absorbed by all biological tissue including enamel and dentin.[13]

The hard tissue excavation have the capability to prepare enamel, dentin, caries, cementum, and bone in addition to cutting soft tissue. These hard tissue laser reduces the problems encountered by the high speed handpiece-vibration, audible whine of the drill, also these lasers reduces the amount of local anesthesia for the procedure so it is boon for all the needle phobic patients.[14] Light emitted by Er:YAG laser is strongly absorbed by water resulting in rapid and expansive vaporization of water in dentine causing explosive dissociation of gross structure.

At the tissue interface, microfragments of tooth structure are ejected within the laser plume causing a pressure change within the immediately surrounding air, resulting in an audible 'popping' sound. In carious tissues, where the water content is greater, this popping sound is correspondingly louder, so that sound can be used to aid the clinician when selecting between ablation of healthy or carious dentine.

Sound resonance is greater when ablating dentine than for enamel, reflecting differences in water content, and ablation proceeds faster in dentine allowing lower power settings to be used. Er:YAG radiation penetrates as much as 100 mm into dentine but the explosive outward effect results in minimal thermal diffusion into the tooth. In grossly carious dentine there is potential for the laser beam to quickly pass through the surface layer, leading to dehydration of deeper layers.[12] The ability of a restorative material to achieve a strong and durable bond with the tooth structure is very important for clinical success so a complete removal of infected dentin is a must to achieve this goal.[15] Restoration of the cavity with adhesive material depends upon the final dentin surface characterstic i.e. surface roughness, presence of smear layer. This affects the final bond and seal achieved by adhesive systems.[16]

The adhesive can be of two types etch and rinse system and self etching adhesive systems.[16] Different from etch and rinse adhesives, self-etch adhesives do not require a separate etching step as they contain acidic monomers that simultaneously condition and prime the dental substrate. Consequently, this approach has been claimed to be user friendlier and less technique sensitive, thereby resulting in a reliable clinical performance. This requires shorter application time, less steps and less technique sensitive because of no wet bonding but simple drying. Comparatively with the self-etch adhesives there is lower incidence of post-operative sensitivity experienced by the patient. This should to a great extent be attributed to the less aggressive and thus more superficial interaction with the dentin leaving tubules largely obstructed with smear layer.[17]

DH Pashley (1995) found that the presence of mineral content within the tubules of caries affected dentin, would prevent the formation of resin tags in dentinal tubules, and it is believed that tags are thought to contribute to bond strength.[18] Self etching adhesive system have been used to simplify adhesive procedure as it decreases technique sensitivity.[19]

The self etch approach is the use of self etching primer in which the acid and the primer are combined in one solution to form a highly hydrophilic and acidic monomers that make hybrid layer more permeable and sensitive to water sorption from the underlying dentin.[20] The smear layer in carious affected dentin may be more resistant to the action of self etching primer as they include acid resistant crystals and extrinsic proteins that might have permeated into the mineral phase during demineralization cycle.[21] If the residual smear layer is left on the surface, the adhesive resin will bond to crystals within it rather than to underlying dentin.[22] Moreover the acidity of the primer could also be influenced by the mineral content of the smear layer.[23]

The prepared surface using rotating or mechanical instruments produces the smear layer. This consists of amorphous layer of organic and inorganic debris with a thickness ranging from 3-10 microns. This prevents resin from adhering to dentin. In order to obtain adequate bonding to dentin this smear layer should be removed or treated prior to the restoration. This can be done by using self etching adhesive systems.[22]

Microtensile bond strength testing is one of the most commonly used method to mechanically assess the strength of resin dentin interface complex. There are two types: macro and micro depending upon the size of the bonded area. The performance of enamel and dentin adhesive can be investigated by shear or tensile bond strength.[24] The laser initially vaporizes water and the other hydrated organic component of the dentin during the process internal pressure increases in the dentin until the explosive destruction of the inorganic substance occur. Since the intertubular dentin contains more water and has a low mineral content than the peritubular dentin it is selectively more ablated than the peritubular denin leaving protruding dentinal tubules with a cuff like appearance.[25]

Thus it would be expected to have better bond strength to irradiated dentin. However not only the morphology of dentin surface is important for bonding but also the chemical composition of the intertubular dentin is also an important factor. During the bonding procedure this dentin is demineralized and then permeated by the hydrophilic monomers, the bonding resin composite then hybridize with the network of collegen fibers, thus the bonding to irradiated dentin was less than the other groups . It is assumed that the composition of the intertubular dentin has been modified by the laser irradiation. This could have lead to a dentin more resistant to demineralization, impairing the action of the mild ph hydrophilic primer used.[14] This is in consensus with the present study.

Conclusion

Within the limitation of this study it was concluded that the surface remaining after mechanical caries excavation and bonding with mild self etching adhesive seems to be compatible allowing deeper penetration of the adhesive and resulted in a thick and homogenous hybrid layer.

References

1. Yazici AR, Özgünaltay G, Dayangaç B. A scanning electron microscopic study of different caries removal techniques on human dentin. Oper Dent 2002;27(4): 360-366.
2. de Almeida Neves A, Coutinho E, Cardodo MV, Lambrechts P, Van Meerbeek B. Current concepts and techniques for caries excavation and adhesion to residual dentin. J Adhes Dent 2011;13(1):7-22.
3. Ceballos L, Camejo DG, Victoria Fuentes M, Osorio R, Toledano M, Carvalho RM *et al.* Microtensile bond strength of total-etch and self-etching adhesives to caries-affected dentine. J Dent 2003;31(7):469–477.
4. Tsanova STs, Tomov GT. Morphological changes in hard dental tissues prepared by Er:YAG Laser (Lite Touch, Syneron), Carisolv and rotary instruments. A scanning electron microscopy evaluation. Folia Medi (Plovdiv) 2010;52(3):46-55.
5. Tyas MJ, Anusavice KJ, Frencken JE, Mount GJ. Minimal intervention dentistry – A Review. FDI Commission Project 1-97. Int Dent J 2000;50(1):1-12.
6. Fusayama T. Two layers of carious dentin; diagnosis and treatment. Oper Dent 1979;4(2):63-70.
7. Kidd EA. How 'clean' must a cavity be before restoration? Caries Res 2004;38(3):305–313.
8. Neves Ade A, Coutinho E, Cardoso MV, De Munck J, Van Meerbeek B. Micro-tensile bond strength and interfacial characterization of an adhesive bonded to dentin prepared by contemporary caries-excavation techniques. Dent Mater 2011;27(6):552–562.
9. Neves Ade A, Coutinho E, De Munck J, Van Meerbeek B. Caries-removal effectiveness and minimal-invasiveness potential of caries-excavation techniques: A micro-CT investigation. J Dent 2011;39(2):154–162.
10. Yip HK, Samaranayake LP. Caries removal techniques and instrumentation: A review. Clin Oral Invest 1998; 2(4):148–154.
11. Banerjee A, Watson TF, Kidd EA. Dentine caries excavation: a review of current clinical techniques. Br Dent J 2000;188(9):476-482.
12. Schwass DR, Leichter JW, Purton DG, Swain MV. Evaluating the efficiency of caries removal using an Er:YAG laser driven by fluorescence feedback control. Arch Oral Bio 2013;58(6):603–610
13. Lee BS, Lin PY, Chen MH, Hsieh TT, Lin CP, Lai JY *et al*. Tensile bond strength of Er,Cr:YSGG laser-irradiated human dentin and analysis of dentin–resin interface. Dent Mater 2007;23(5):570–578.
14. Tachibana A, Marques MM, Soler JM, Matos AB. Erbium, chromium:yttrium scandium gallium garnet laser for caries removal: influence on bonding of a self-etching adhesive system. Lasers Med Sci 2008;23(4):435–441.
15. Silva NR, Calamia CS, Harsono M, Carvalho RM, Pegoraro LF, Fernandes CA *et al*. Bond angle effects on microtensile bonds: Laboratory and FEA comparison. Dent Mater 2006;22(4):314–324.
16. da Graca Lopes RM, Steiner-Oliveira C, Correa Aranha AC, Castellan CS, Bello Silva MS, VieiraND Jr *et al*. Microtensile bond strength to Er:YAG laser pretreated dentin. Braz Dent Sci 2014;17(1):54-61.
17. Van Meerbeek B, Yoshihara K, Yoshida Y, Mine A, De Munck J, Van Landuyt KL. State of the art of self-etch adhesives. Dent Mater 2011;27(1):17-28.
18. Tao L, Pashley DH, Boyd L. Effect of different types of smear layers on dentin and enamel shear bond strengths. Dent Mater 1988;15(4):208-216.
19. Paranhos MP, Spohr AM, Marcondes M, Oshima HM, Mota EG *et al*. Influence of Nd:YAG laser irradiation on microtensile bond strength of adhesive systems to sound or carious dentin. Quintessence Int 2009;40(2):145-153.
20. Tay FR, King NM, Suh BI, Pashley DH. Effect of delayed activation of light-cured resin composites on bonding of all-in-one adhesives. J Adhes Dent 2001;3(3):207-225
21. Yoshiyama M, Urayama A, Kimochi T, Matsua T, Pashley DH. Comparison of conventional vs self-etching adhesive bonds to caries-affected dentin. Oper Dent 2000;25(3):163-169.
22. Banerjee A, Kidd EA, Watson TF. Scanning electron microscopic observations of human dentine after mechanical caries excavation. J Dent 2000;28(3):179–186.
23. Itou K, Torii Y, Suzuki K, Nakai H, Inoue K. Adhesion of restorative resin to tooth. Adhesion Promoted by Liner Bond II. Adhes Dent 1994;12(3):174-181
24. Salz U, Bock T. Testing adhesion of direct restoratives to dental hard tissue - A review. Adhes Dent 2010;12(5):343-371.
25. Aoki A, Ishikawa I, Yamada T, Otsuki M, Watanabe H, Taqami J *et al*. Comparison between Er:YAG laser and conventional technique for root caries treatment in vitro. J Dent Res 1998;77(6):1404-1414.

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