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TO EVALUATE AND COMPARE LENGTH OF RESIN TAG FORMATION AT THE TOOTH-COMPOSITE INTERFACE AFTER USING DIFFERENT TEETH FINISHING SYSTEMS THAT INCLUDES COMPOSITE FINISHING BURS, CARBIDE BURS AND ND: YAG LASERS

Dr. Swapnil Khadtare[1], Dr. Ishan Ahmed*[2], Dr. Shalini Aggarwal[3], Dr. Poorva Kurtarkar[4], Dr. Rhea Digholkar[5], Dr. Tushita Pandey[6]

India.

***Corresponding Author: Dr. Ishan Ahmed**
MDS (Conservative Dentistry and Endodontics).
Email ID: ahmedishan4@gmail.com,

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1) ABSTRACT

Objectives: The aim of this study was to determine and compare resin tag length at tooth composite restoration after using three different cavity finishing systems. **Materials and Methods:** Sixteen extracted intact maxillary or mandibular teeth were selected and divided into 4 groups (n=4) as Group 1: control group no cavity finishing system used, Group 2: Carbide burs (Mani) used, Group 3: Composite burs(Mani) used, Group 4: Nd:YAG Laser (Epic X, Biolase) used. Class 5 cavities of same dimensions were prepared on buccal surface of each sample. Mass of 0.5% Rhodamine dye added to bonding agent after using cavity finishing systems and composite restorations were done. The specimens were sectioned Labio-lingual manner and processed for viewing under CLSM to obtain images of bonded interfaces. One way ANOVA test with Tukey Kramer multiple comparison test was applied to test the comparison of all groups together at 5% (p=0.05) and 1% (p=0.01) level of significance. **Results:** Length of resin tag was significantly influenced by cavity finishing systems. Group 3 had maximum depth of resin penetration 432.67±58.00 μm followed by Group 4 at 382.52±43.44 μm, Group 2 at 235.43±19.33and Group1 that was control group was least having minimum value 187.44±19.87 μm. The results from this study concluded that composite cavity finishing system and Nd:YAG lasers produced best results. **Conclusions:** The use of composite finishing system as well as lasers before resin composite restorations results into longer resin tag penetration, which contribute to better bond strength, and lesser incidence of cohesive failure.

KEYWORDS: Confocal Laser Scanning Microscope; Dentin Pretreatment; Interdiffusion zone; Resin tags.

1) INTRODUCTION

The concept of adhesion was given by Buonocore[1] in 1955, enamel etching and penetration of polymerizable resin based materials into spaces created by resin tags are responsible for micromechanical retention.

Adhesive dentistry is a rapidly evolving field. The application of these systems has profoundly changed the way dentistry is delivered. Close adaptation of the restorative material to the prepared tooth surface goes a long way in eliminating restorative failure and is highly technique sensitive.

Proper finishing of the prepared tooth surface could ensure enhanced bonding to the restorative material. Micro mechanical retention is primarily facilitated by resin infiltration into partially demineralized dentin leading to the formation of a hybrid layer and resin tags, which in turn influence the strength of the restoration. The need to establish a reliable technique to attain this has prompted us to undertake a study in which tooth preparations finished with different systems are evaluated and cross- compared for length of resin tag formation at the tooth resin interface.

Stable adhesion between composite and dentin substrate is primary factor to clinical success of restorations because failure of adhesion can leads to nano-leakage that can result in secondary caries.

Smear layer produced in dentin affected by caries possess acid resistance crystals which decreases infiltration of primer into dentin substrate, this layer acts as an obstruction impairs permeability of resin monomers into demineralized dentin. Various dentinal surface pretreatments and characteristics of dentinal substrate may results in resin tag formation inside dentinal tubules, branching or micro-tags and formation of smear layer which is mainly responsible for micromechanical retention.[2] Type of bonding agent, application technique and finishing and polishing of restoration these are secondary factors.

2) MATERIALS AND METHODS

16 extracted non carious molar teeth were selected and decoronated

The prepared samples were then divided into 4 groups-

GROUP 1- Cavity prepared and no finishing system shall be used.

GROUP 2 – Cavity finished with carbide finishing burs (Mani).

GROUP 3 – Cavity finished with composite finishing burs(Mani).

GROUP 4 – Cavity finished with Nd: YAG LASER (Epic X, Biolase)

A 4mm x 4mm x 2mm cavity wereprepared on the intact surface / buccal surface of the each sample.

A mass of 0.5% of Rhodamine B fluorescent dye were added to bonding agent prior to application to dentin surfaces. For each bonding condition two dentin slices (2 mm in thickness) were obtained, and the same bonding procedure used.[13]

The specimens were sectioned Labio-lingual manner and processed for viewing under CLSM to obtain images of bonded interfaces, focusing on thickness of bonding agent, formation of collagen-resin hybrid layer, and penetration of resin into dentinal tubule.

Statistical analysis was done by descriptive statistics as mean, SD, percentage / proportions.

Comparisons was done by applying Student's Unpaired 't' test at 5% (p=0.05) and 1% (p=0.01) level of significance.

Also, One way ANOVA test with Tukey Kramer multiple comparison test was applied to test the comparison of all groups together at 5% (p=0.05) and 1% (p=0.01) level of significance.

3) RESULTS

Table 1: Comparison of mean and SD values of Length of resin tags (in µm) in Group 1(Control), Group 2((Amalgam finishing system), Group 3((Composite finishing system) and Group 4(LASER).

(n=4)	GROUP 1 (CONTROL)	GROUP 2 (Amalgam finishing system)	GROUP 3 (Composite finishing system)	GROUP 4 (LASER)
Mean ± SD	187.44±19.87	235.43±19.33	432.67±58.00	382.52±43.44

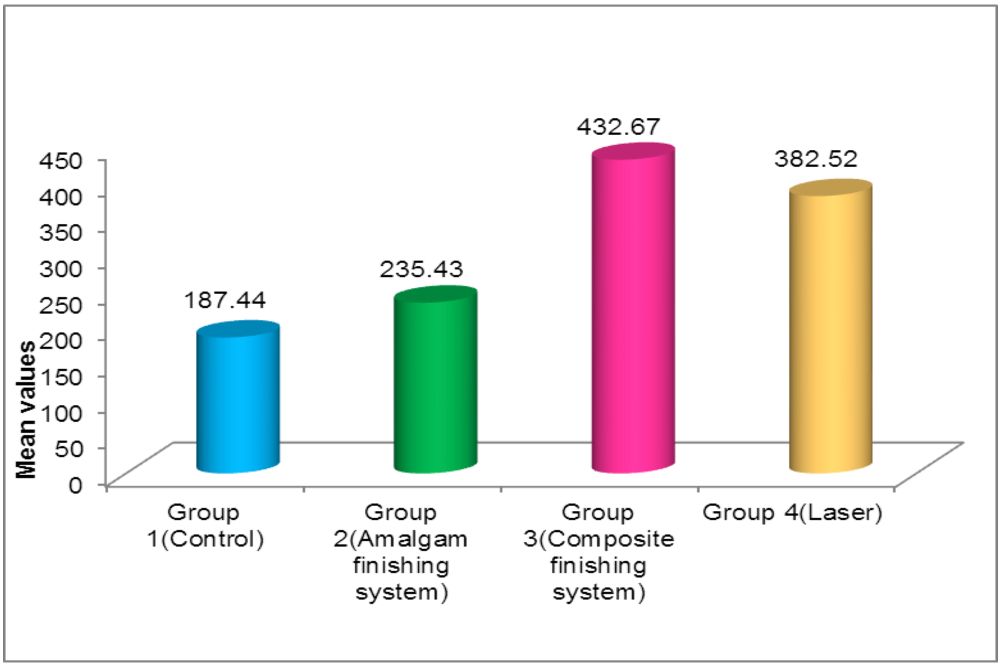


Fig 1: Comparison of mean values of Length of resin tags (in µm) in Group 1(Control), Group 2(Amalgam finishing system), Group 3(Composite finishing system) and Group 4(Laser)

Group 3 had maximum depth of resin penetration **432.67 µm** followed by Group 4 at **382.52 µm,** Group 2 at 187.44 µm and Group1 that was control group was least having maximum value 187.44 µm.

The results from this study concluded that composite cavity finishing system and Nd:YAG lasers produced best results.

Statistical analysis was done by descriptive statistics as mean, SD, percentage / proportions.

Comparisons was done by applying Student's Unpaired 't' test at 5% (p,0.05) and 1% (p,0.01) level of significance.

Also, One way ANOVA test with Tukey Kramer multiple comparison test was applied to test the comparison of all groups together at 5% (p,0.05) and 1% (p,0.01) level of significance.

Statistical analysis software namely SYSTAT version 12 (By Cranes software, Bangalore, India) was used to analyze the data.

4) DISCUSSION

Dr. Oskar Hagger in the 1950s was the first to experiment with bonding of self-cured acrylic resins to the tooth structure. Dr. Michael Buonocore further refined this technique, when he used phosphoric acid to roughen the surface of the tooth to allow for micro-mechanical retention.

The application of Adhesive Dentistry has since then scaled various peaks, bringing it to a point where it is possible to view the intermingling of the substrate (enamel/ dentin) with the Dental Adhesive at high magnifications and catalogue their characteristic features.

It was further determined that the acid etching of the tooth led to a reduction in the physical properties of the enamel and the dentin.

Goncalves et al (2014)[6] reported that different bonding systems gives different hybrid layer thickness on surfaces prepared with drills or LASER. They also observed that monomers can penetrate into deeper dentin and can flow laterally resulting in small lateral remi called as micro tags. Etching by itself is a step that is often taken very lightly and pre-treatment of the substrate prior to etching is another vastly over-looked step. The contention of this study was that certain pretreatments could be tried in order to improve upon the etching and thereby the subsequent hybridization.

Ideally these roughened areas should be saturated completely with the Dental Adhesive in order to restore to some extent the physical properties of the demineralized tooth substrate. The reality however isn't the same as the hypothetical and in a hybrid layer there are various zones that can be isolated. The zone closest to the substrate is the demineralized zone that has been only partially impregnated with the dental adhesive. It is in this zone that cohesive fractures were seen when debonding of the composite restoration was examined.

Zafar M et al (2015)[7] concluded that etching time of enamel directly affect surface roughness as etching time increases, surface roughness increases and decrease in surface hardness compromising the bond strength.[7] Etching of enamel surface in 15 sec showed best results in micromechanical retention without compromising microleakage in enamel surface.[1][4-6] M.T. Schein et al.(2003)[8] compared acid etching pattern after using rotary drills and LASERS on morphological analysis it was concluded that acid etching after rotary drills formed porous surface, with increase in permeability also resulted in nonometer sized porosities for resin penetration while in case of acid etching after LASER application to cavity resulted in porous network of dentinal surface and subsurface, dentinal surfaces were lined by peritubular dentin, which was unable to remove from acid etching. Eliades[1] contends that the impregnation of the etched dental hard tissues could be improved upon by ensuring that the etchant comes in close contact with the substrate to be etched. No voids in the etchant itself or impurities and irregularities on the substrate should impede the close contact of the etchant with that of the substrate being etched. Thus, the more controlled the etching; more regular shall be the demineralized tissue. The viscosity of the etchant itself is one of the major deterrents to the formation of a regular surface. Thereby, leaving the dental adhesive with the herculean task of penetrating the etched zone adequately. Added to this mix is the fact that the Dental Adhesive has its own flow properties and curing characteristics. To this end Eliades[1] has proposed that various pre-treatments prior to etching can be used to create a layer of uniform pits and craters, with approximately the same depth.

M.J.Shinchi*et al* (2000)[9] concluded that higher concentrations of Phosphoric acid can result in lowering of resin tag length. Hence 37% Phosphoric acid was used for etching. Hashimoto et al (2000)[10] concluded that prolonged acid conditioning could results in demineralized dentin zone, which is most favorable for cohesive failure. So 15 seconds time was used for acid etching in this study.

An adhesive were applied in two coats and was thinned by high-pressure air blowing. **Chen *et al* (2014)[11]** evaluated that high pressure air blowing that was 0.4 Mpa for 5 sec at distance of 20 mm from dentin surface resulted in longer, homogenous and less interrupted resin tags. Another study by **Spencer P *et al* (2002)[12]** revealed that resin tag composition is also important factor when considering bond strength. When simplified adhesives were applied on etched wet dentinal tissues, deeper migration of molecules with lower molecular weight these are the hydrophilic monomers which cure weakly contribute to lesser bond strength.

In order to study resin tag penetration, we selected commercially available adhesive, which represents 'etch and rinse' approach. The purpose to use of Etch and rinse approach was to produce better tag penetration inside prismatic enamel structure as enamel have highest inorganic component it was possible to have high buffering capacity against acidic monomers. Non rinsing self etch adhesives could be less aggressive to penetrate through smear layer.[1]

When restorative procedures were conducted by cavity finishing burs it was seen that hybrid layer thickness was greater as compared to Nd:YAG LASER treated surface. But in LASER treated group resin tags were uniform, uninterrupted than other three groups. **M.T. Schein et al. (2003)[9]** observed that when rotary burs were applied in cavity preparations before etching it resulted into resin tag anastomosis and sealing of tubules which of prime importance in resin penetration in deepest demineralized zone of dentin, while in case of LASERS seems to be adversely affected on dentin hybridization formed less hybridization zones also did not show opening of collagen which essential for interdiffusion zones. Contradictory to these results **Aranha et al (2007)[18]** concluded that resin tags were more uniform, longer in lased dentin than bur prepared dentin. In the present study all the groups showed gap formation between resin and dentin interface, which is indicative of collagen alteration as observed in previous studies.[18]

Peerzada et al(2010)[19] showed in their study that higher bond strength was achieved when tungsten carbide burs were used on dentinal surfaces before adhesive application. It was observed that tungsten carbide burs allows a smoother surface with lesser debris while in case of diamond coated bur produces remarkable roughness on treated surface which is proportional to granulosity of the diamond and non-homogenous insertion of diamond particles to the surface of the bur which forms higgledy microscopic furrows. Such uneven patterns lead to an improper contact of the etchant with the tooth substrate resulting in an unproductive micro porosity pattern. **J.A. Barros et al (2005)[20]** compared dentine surfaces treated with diamond burs and carbide cavity cutting burs, diamond burs showed thick, uneven smear layer as compared to carbide cavity cutting burs. But some studies showed that smear layer removal did not guarantee greater bond strength but these factors such as pretreatment of dentinal substrate, Etching type, type of adhesive used, technique of adhesive application plays important role in adhesion.[21] Composite finishing burs showed best result in this study, rotary burs give more surface roughness, which results in greater surface area and wettability.[22] In most of the previous studies 600-grit SiC sand paper was used for dentin surface to standardize the surface, However this method produces a very flat, smooth surface due to which smear layer produced in clinical situation was not achieved.[13] In present study clinical scenario was reproduced including burs and LASERS that are commonly used for cavity preparation. Results obtained from his study were contradictory to some studies, which stated that bur cut dentin produces very shortly projected, unequally distributed resin tags regardless of application time.[18]

(5) Tables

Table No. 1: Comparison of mean and SD values of Length of resin tags (in micro-meter) in Group 1(Control), Group 2((Amalgam finishing system), Group 3((Composite finishing system) and Group 4(Laser).

(n=4)	GROUP 1 (CONTROL)	GROUP 2 (Amalgam finishing system)	GROUP 3 (Composite finishing system)	GROUP 4 (LASER)
Mean ± SD	187.44±19.87	235.43±19.33	432.67±58.00	382.52±43.44

Table No. 2: Comparison of mean and SD values of Length of resin tags (in micro-meter) in Group 1(Control), and Group 2((Amalgam finishing system).

Resin tag length	GROUP 1 (CONTROL)	GROUP 2 (Amalgam finishing system)	Student's Unpaired 't' test value	'p' value and significance
Mean ± SD	187.44±19.87	235.43±19.33	3.46	p=0.001, significant

Table No. 3: Comparison of mean and SD values of Length of resin tags (in micro-meter) in Group 1(Control), and Group 3((Composite finishing system).

Resin tag length	GROUP 1 (CONTROL)	GROUP 3 (Composite finishing system)	Student's Unpaired 't' test value	'p' value and significance
Mean ± SD	187.44±19.87	432.67±58.00	7.99	p=0.001, significant

Table No. 4: Comparison of mean and SD values of Length of resin tags (in micro-meter) in Group 1(Control), and Group 4 (Laser).

Resin tag length	GROUP 1 (CONTROL)	GROUP 4 (LASER)	Student's Unpaired 't' test value	'p' value and significance
Mean ± SD	187.44±19.87	382.52±43.44	8.16	p=0.001, significant

Table No. 5: Comparison of mean and SD values of Length of resin tags (in micro-meter) in Group 2((Amalgam finishing system) and Group 3 (Composite finishing system).

Resin tag length	GROUP 2 (Amalgam finishing system)	GROUP 3 (Composite finishing system)	Student's Unpaired 't' test value	'p' value and significance
Mean ± SD	235.43±19.33	432.67±58.00	6.45	p=0.001, significant

Table No. 6: Comparison of mean and SD values of Length of resin tags (in micro-meter) in Group 2((Amalgam finishing system) and Group 4(Laser).

Resin tag length	GROUP 2 (Amalgam finishing system)	GROUP 4 (LASER)	Student's Unpaired 't' test value	'p' value and significance
Mean ± SD	235.43±19.33	382.52±43.44	6.19	p=0.001, significant

Table No. 7: Comparison of mean and SD values of Length of resin tags (in micro-meter) in Group 3(Composite finishing system) and Group 4(Laser).

Resin tag length	GROUP 3 (Composite finishing system)	GROUP 4 (LASER)	Student's Unpaired 't' test value	'p' value and significance
Mean ± SD	432.67±58.00	382.52±43.44	1.38	p=0.547 Not significant

ONE WAY ANOVA TEST

1. **For group 1,2,3 and 4 together**

Source of variation	d.f.	Sum of squares	Mean square
Treatment (Between columns)	3	163066	54355
Residuals (Within columns)	12	18050	1504.2
Total	15	181116	

Value of F = 36.137, p=0.001, significant

2. **For group 2,3, and 4together**

Source of variation	d.f.	Sum of squares	Mean square
Treatment (Between columns)	2	84071	42036
Residuals (Within columns)	9	16885	1873.9
Total	11	100936	

Value of F = 22.432, p=0.001, significant

3. **For group I (a), II (a), III(a), and I (b), II (b), III(b) together**

Source of variation	d.f.	Sum of squares	Mean square
Treatment (Between columns)	5	1530097	306019
Residuals (Within columns)	54	447232	8287.6
Total	59	1977629	

Value of F = 36.925, p=0.001, significant

Table no. 8

Mechanical property	Mineralized dentin	Demineralized dentin
Microtensile strength (MPa)*	60–100 50-55 (Caries affected)	10–25 14-16 (Caries affected)
Modulus of elasticity*	13–18 Gpa	50–70 MPa
Microhardness (Knoop)	60–70	40–50
Density (g/cm^3)	2.01	1.05

(6) Figures

Samples prepared for confocal laser scanning microscope.(fig.7)

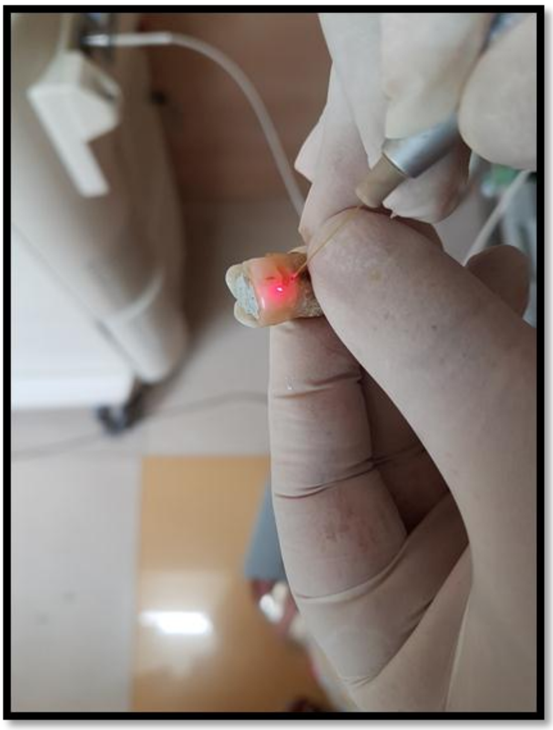
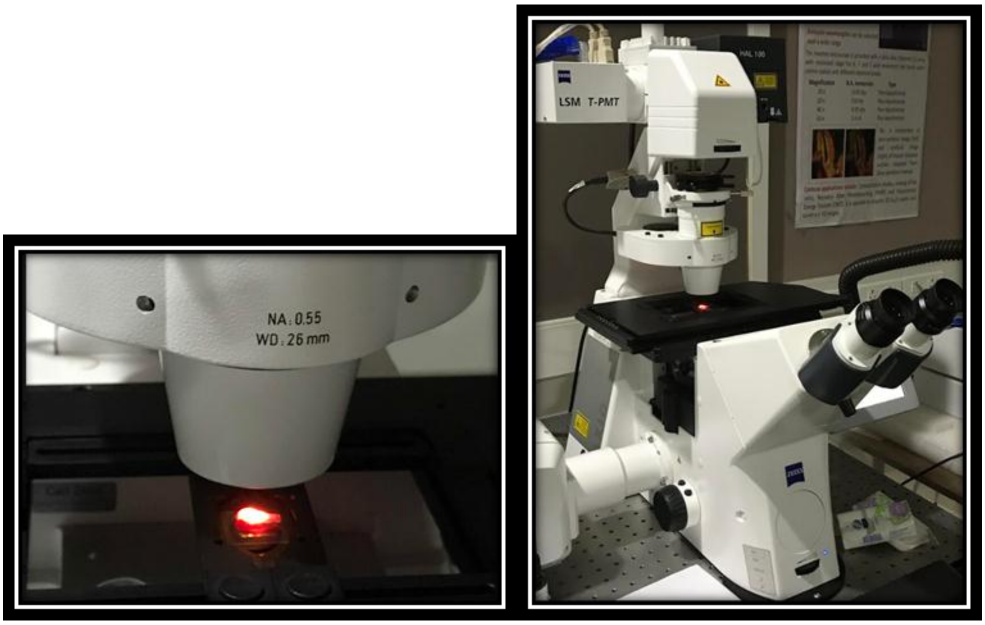


Figure 5: Nd:YAG LASERS treated cavity surfaces.



Samples viewed under confocal laser scanning microscope (fig 8)

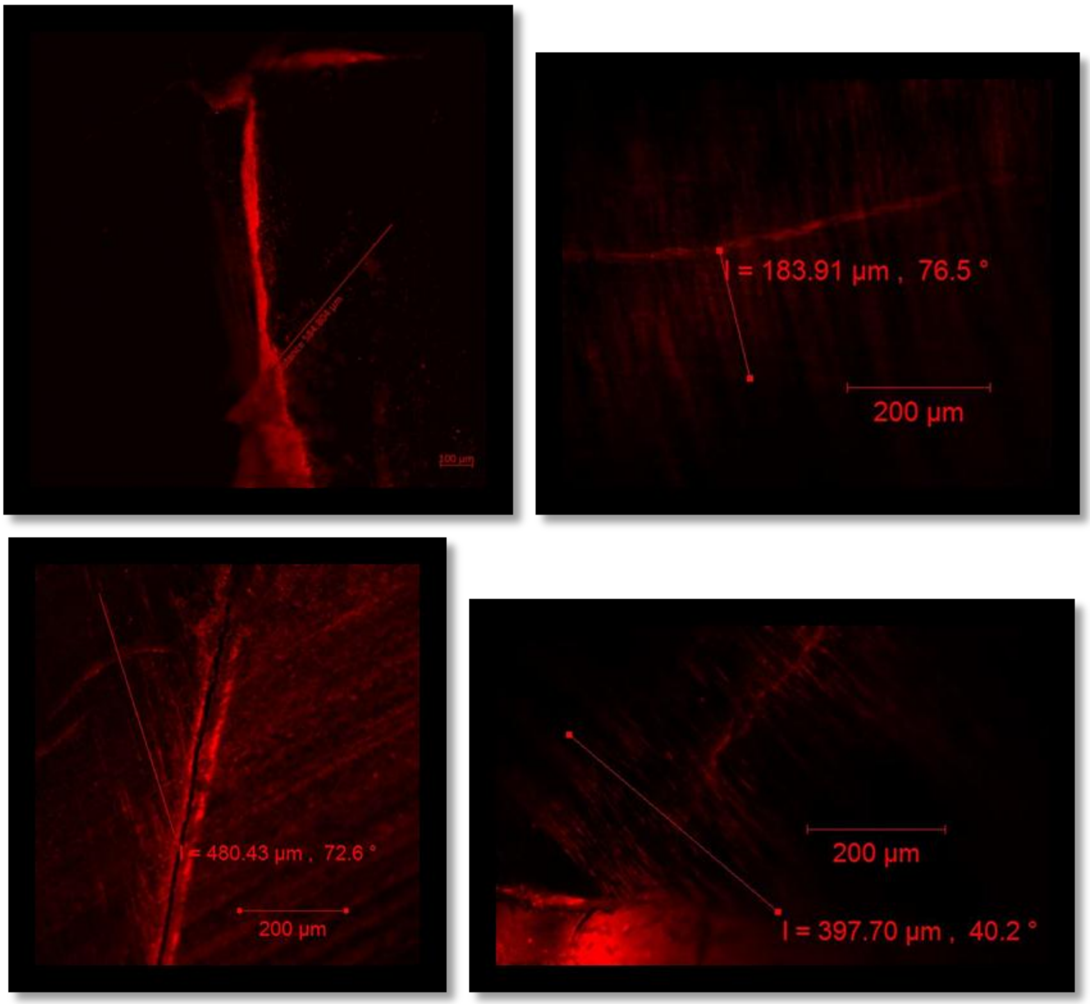


Fig 9: CLSM Images (a) Control group (b) Amalgam finishing system (c) Composite finishing system (d) Nd:YAG LASER.

(7) CONCLUSION

It can be concluded that use of composite finishing system as well as lasers before resin composite restorations results into longer resin tag penetration, which contribute to better bond strength, and lesser incidence of cohesive failure.

In present study clinical scenario was reproduced including burs and LASERS that are commonly used for cavity preparation. Results obtained from his study were contradictory to some studies, which stated that bur cut dentin produces very shortly projected, unequally distributed resin tags regardless of application time.[18]

(8) ACKNOWLEDGEMENT

Author's Contribution: Conceptulization: Khadtare S, Ahmed I, Aggarwal S, Kurtarkar P, Digholkar R

ORCID iD

Dr.Swapnil Khadtare https://orcid.org/0000-0002-2134-7260

Dr.Ishan Ahmed https://orcid.org/0000-0002-5234-8741

Dr.ShaliniAggarwal https://orcid.org/0000-0001-9522-6560

Dr.PooorvaKurtarkar https://orcid.org/0000-0002-1842-9548

Dr.RheaDigholkar https://orcid.org/0000-0003-4248-3189

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