

Effectiveness of Paprika Dye for Disclosing Composite in Enamel and Dentin – An Invitro Study

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Abstract:

Background: Composite discoloration, recurrent caries and microleakage causing sensitivity are the common reasons for replacing dental composites. A disclosing agent that only stains the composite or stains it more than the tooth would help in identifying the boundaries of composite and facilitate its replacement. Paprika dye can effectively stain various composites from enamel and dentin, preventing tooth loss by precisely identifying tooth restorative margins.

Aim: To evaluate the Effectiveness of Paprika dye for disclosing flowable and short fiber reinforced composite resin in enamel and dentin.

Materials and Methods: Forty extracted maxillary premolars were selected and divided into four groups based composite placement in enamel and dentin: flowable composite resin in enamel, short fiber reinforced composite resin in enamel, flowable composite resin in dentin, short fiber reinforced composite resin in dentine. Standardized Class I and Class V cavities were prepared, bonded, and restored using short fiber reinforced composite (everX Posterior) and flowable composite. The samples were thermo-cycled and immersed in Paprika dye. Baseline color values were determined for both the tooth and the composite individually using spectrophotometer prior to staining and after staining.

Results: The results concluded that paprika dye is effective in staining flowable and short fiber reinforced composites in underlying enamel and dentin substrates. Flowable composite resin showed greater staining intensity than Short Fiber Reinforced resin.

Conclusion: Paprika dye is effective in staining flowable and short fiber reinforced composites in underlying enamel and dentin substrates.

Key Word: Dentin, Flowable Composite, Paprika dye, Shade Analysis, Short Fiber Reinforced Composite

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I. INTRODUCTION

Composites are routine esthetic restorations in dental practice all around the world.¹ Availability in various tooth colored esthetic shades, good mechanical properties and bonding to enamel and dentine substrates makes composites very demanding in dentistry today.² The appropriate and durable matching of color to neighboring dental structures and other aesthetic restorations, while assessing their impact on the final tooth color, is crucial to the effectiveness of composite.³ The possibility to complement these composites with the biological hue of teeth has greatly increased due to the extensive range of colors available.⁴ The color stability of resin composites is influenced by a variety of elements, including surface polish, water absorption, chemical interactions within the resin, and the type of food coloring that can produce both intrinsic and extrinsic color shifts.⁵ Dental plaque buildup, food coloring stains, dehydration, smoking, surface roughness and oxidation of unreacted carbon double bonds are some of the causes of external discoloration which demands composite replacement in clinical situations.^{6,7}

Composite discoloration due to intrinsic and extrinsic factors, secondary caries, and microleakage causing sensitivity are the most common reasons for re restorations. Conservative removal of such restorations during re-restorations without significantly removing tooth structure can be time consuming, and stressful for the dental practitioner. Also, in patients undergoing fixed orthodontic treatment, composite remains bonded to the tooth enamel after debonding of brackets which is difficult to detect and remove.⁸

There is a possibility that more natural tooth structure will be lost after their removal, which could weaken the tooth or jeopardize the remaining dentin thickness.⁹ Composite disclosing dye would help the practitioner to differentiate the boundary of composite with tooth and remove such restorations without damaging the adjacent healthy tooth structure.¹⁰ Hydrophobic dyes having varying affinities for the surfaces of enamel, dentine and composite, can be used as a revealing agent for old and residual composite.¹¹

Composite removal is usually done by visual examination, which is highly subjective and imprecise and fluorescent methods are not reliable because of modest fluorescence qualities of composites, need of dark environment for visualization and risk of damage to the operator's eyesight.¹²

Compared to direct and indirect restorative procedures, the injectable composite technique has drawn interest due to its ease of use, affordability, and lower requirement for physician competence.¹³

Flowable composites are routinely used for restoring cervical carious and non-carious lesions and also as liners in deep cavities involving dentin to reduce polymerization shrinkage. Short fiber reinforced composites are used as dentin replacement material in recent times due to their strength properties. Hence, these composites types are selected in the study.

Advances in material science have enabled the development of novel dyes that can stain composites independently of external light sources. Diverse plant derived natural dyes are often nontoxic cost-effective and readily available. Paprika red pigment is a natural dye mostly derived from desiccated chili peppers.²

The evaluation of color stability in dental composite materials has also been greatly aided by developments in measurement techniques.¹⁴ Instrumental and visual methods can be employed to assess variations in color of restorative materials. Inter observer variations in color perception have been cited as the reason for visual color judgement unreliability. For the purpose of determining color changes in dental materials and providing an objective interpretation, instrumental procedures have so been generally preferred.¹⁵ Color measurement tools include colorimeters, spectrophotometers, spectroradiometers, 3D shape software, and digital cameras.

Spectrophotometers have been a common reference tool in several recent color measurement research.¹⁴ Spectrophotometers measure quantity of light reflected from objects across visible spectrum, making them more accurate and systematic.⁹ Because they assess a specimen's transmittance curve or spectral reflectance, spectrophotometers are helpful for determining surface color. By scattering white light via a triangle prism at wavelength intervals of 1 to 25 nm and then reflecting it from the tooth's surface, they are able to capture the full energy of the color spectrum.¹⁶

Many studies are available to differentiate between enamel and composite margins but the effectiveness of these dyes to stain dentin is limited and use of this dye on various types of composites is also limited. Hence the purpose of this study is to determine the effectiveness of paprika dye in the removal of flowable and short reinforced composite in enamel and dentin substrates.

II. MATERIAL AND METHODS

This In-vitro comparative study was carried in the Department of Conservative Dentistry and Endodontics, at Anil Neerukonda Institute Of Dental Sciences, Visakhapatnam, Andhra Pradesh.

Study design: Cross-sectional In-vitro original research

Study location: Department of Conservative Dentistry and Endodontics, at Anil Neerukonda Institute Of Dental Sciences, Visakhapatnam, Andhra Pradesh

Study duration: 2 months

Sample size: 40 maxillary premolar teeth.

Subjects & selection method: 40 recently extracted maxillary teeth.

Inclusion criteria:

- Teeth that underwent therapeutic extraction for orthodontic purposes.

Exclusion criteria:

- Teeth with Caries

- Teeth with fractures
- Demineralization teeth
- Teeth with severe pitting
- Teeth with abnormal intrinsic stains
- Teeth with history of tooth whitening.

Procedure methodology:

Following extraction, teeth were washed and stored in labeled containers containing 10% formalin solution for later examination. Standard box shaped class V cavities were prepared for 20 teeth with a 5 mm mesiodistal width, 2 mm incisio-cervical height and 2 mm depth in all the samples. For other 20 specimens teeth were sectioned in middle third of crown and standard cavity in dentin were prepared 5mm mesiodistal width, 2 mm buccolingual width and 2 mm deep. Cavity preparations were etched for 15s using 37% phosphoric acid (N Etch, Ivoclar vivadent, Asia), then washed for 15s and gently air- dried. Tetric N-Bond (Ivoclar vivadent, Asia) adhesive was applied using the total-etch technique in two consecutive coats, lightly air-dried for 10s, and light polymerized at 1000 mW/cm² for 40 seconds, using light curing unit. Flowable composite and short fiber reinforced composites were used for restoration of cavities.

- Group 1(n= 10): Paprika dye for disclosing flowable composite resin in enamel
- Group 2(n=10): Paprika dye for disclosing short fiber reinforced composite resin in enamel
- Group 3(n=10): Paprika dye for disclosing flowable composite resin in dentin
- Group 4(n=10): Paprika dye for disclosing short fiber reinforced composite resin in dentin

The specimens were then subjected to storage in distilled water and thermo-cycled to simulate ageing process.

Spectrophotometric analysis

Baseline color values were determined for both the tooth and the composite individually using spectrophotometer prior to staining. The color parameters were measured for the composite attachment and tooth separately after staining with paprika dye for all the groups. The ΔE value were calculated based on the color changes pre- and post- staining for both tooth and composite attachment in all four group.

III. FIGURES



Fig 1: Armamentarium of the study



Fig 2: Tooth Sectioning

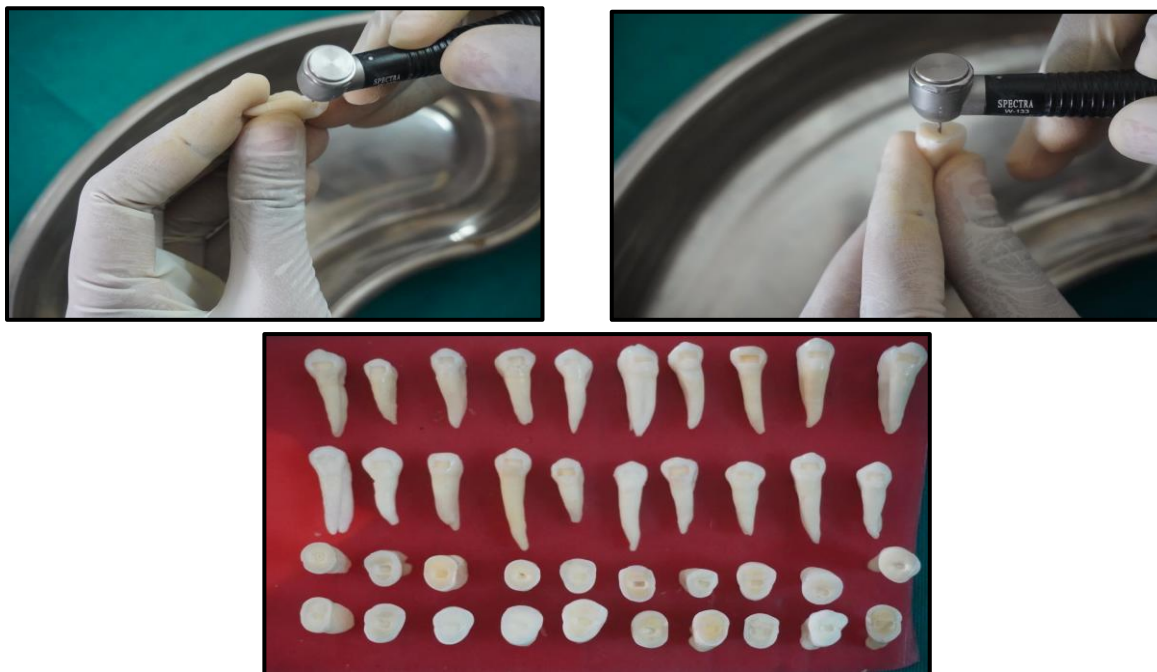


Fig 3: Cavity preparation



Fig 4: Acid etching

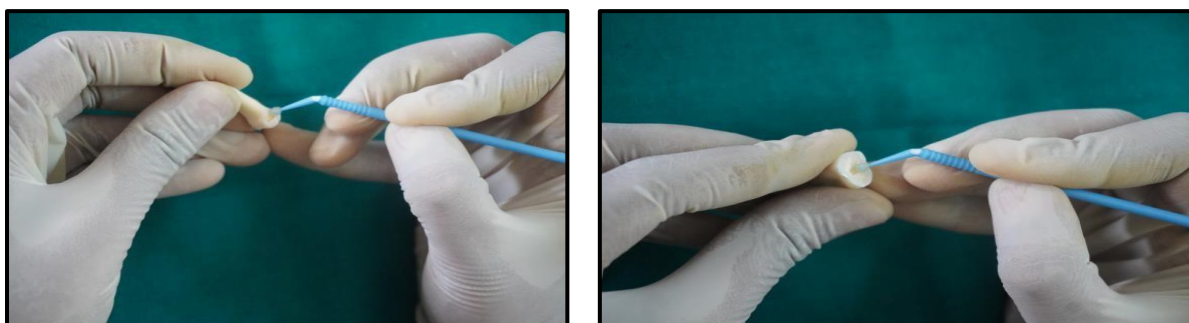


Fig 5: Bonding agent application

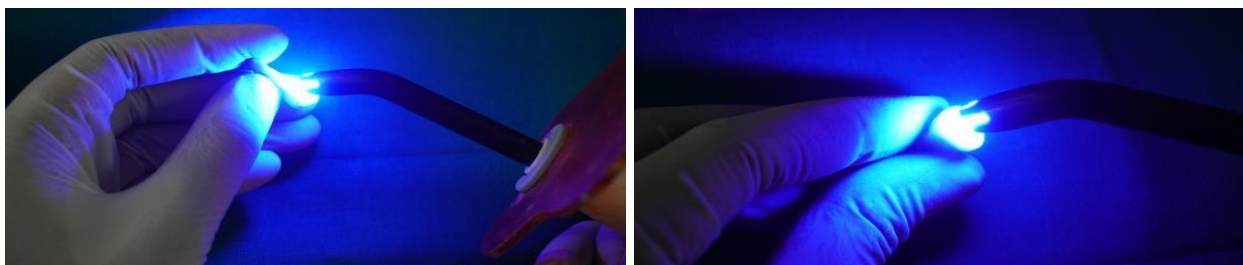


Fig 6: Curing of bonding agent



Fig 7: Flowable Composite Placement



Fig 8: Short Fiber Reinforced Composite



Fig 9: Curing composite



Fig 10: Before staining



Fig 11: After staining



Fig 12: Spectrophotometric Analysis

Statistical analysis

Data were subjected to statistical analysis using IBM SPSS version 26 (ICM Corp, Armonk, NY, USA). For all the statistical tests, $P < 0.05$ was considered to be statistically significant.

III. RESULTS

Table 1:

Group 1: Paprika dye for disclosing flowable composite resin in enamel

		MEAN	STANDARD DEVIATION	MEAN DIFFERENCE	T VALUE	P VALUE
Enamel	before	6.02	0.18	-3.31	-19.12	0.000
	after	9.34	0.51			
Flowable composite	before	17.06	0.29	-18.17	-65.58	0.000
	after	35.23	0.82			

Table 2:

Group 2: Paprika dye for disclosing short fiber reinforced composite resin in enamel

		MEAN	STANDARD DEVIATION	MEAN DIFFERENCE	T VALUE	P VALUE
Enamel	before	6.06	0.26	-3.39	-18.76	0.000
	after	9.45	0.50			
SRS composite	before	14.6	0.30	-14.70	-71.21	0.000
	after	29.33	0.57			

Table 3:

Group 3: Paprika dye for disclosing flowable composite resin in dentin

		MEAN	STANDARD DEVIATION	MEAN DIFFERENCE	T VALUE	P VALUE
Dentine	before	7.30	0.32	-9.87	-83.86	0.000
	after	17.17	0.16			
Flowable composite	before	13.7	0.63	-21.13	-91.51	0.000
	after	34.9	0.35			

Table 4:

Group 4: Paprika dye for disclosing short fiber reinforced composite resin in dentin

		MEAN	STANDARD DEVIATION	MEAN DIFFERENCE	T VALUE	P VALUE
Dentine	before	7.3	0.30	-7.37	-55.81	0.000
	after	14.66	0.28			
SRS composite	before	13.86	0.46	-14.42	-67.24	0.00
	after	28.29	0.49			

Table 5:

Comparing paprika dye effectiveness for disclosing flowable and short fiber reinforced composite resin in enamel and dentin

		MEAN	STD	T VALUE	P VALUE
GROUP 1	Enamel	3.31	0.47	-61.26	0.000
	Flowable composite	18.17	0.59		
GROUP 2	Enamel	3.39	0.56	-48.10	0.000
	Short fiber reinforced composite	14.7	0.48		
GROUP 3	Dentin	6.46	0.41	-74.75	0.000
	Flowable Composite	17.7	0.22		
GROUP 4	Dentin	6.56	0.60	-32.93	0.000
	Short fiber reinforced composite	13.65	0.31		

Table 6:

Enamel and Dentin

TIME	GROUP	MEAN	STD	F VALUE	P-VALUE
BEFORE	1	6.0270	.18732	69.33	0.000
	2	6.0600	.26512		
	3	7.3050	.33287		
	4	7.3080	.30110		
AFTER	1	9.3460	.51584	227.66	0.000
	2	9.4520	.50653		

	3	13.7690	.63574		
	4	13.8660	.46421		

Table 7:
Flowable and Short fiber reinforced composite

TIME	GROUP	MEAN	STD	F VALUE	P-VALUE
BEFORE	1	17.0610	.29618	278.9	0.000
	2	14.6280	.30470		
	3	17.1780	.16665		
	4	14.6670	.28845		
AFTER	1	35.2390	.82494	382.09	0.000
	2	29.3340	.57762		
	3	34.9070	.35966		
	4	28.2930	.49473		

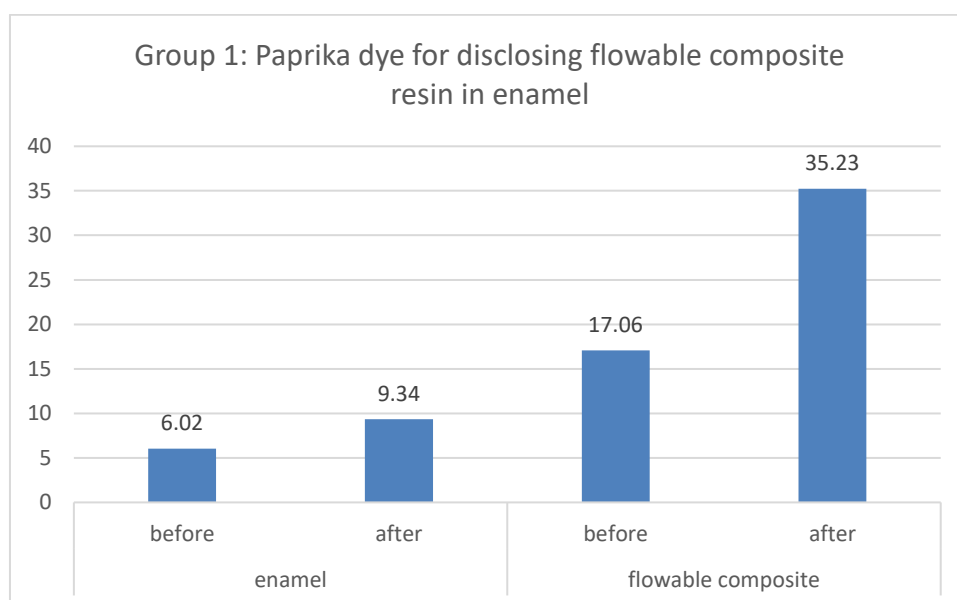


Fig 13: Paprika dye for disclosing flowable composite resin in enamel

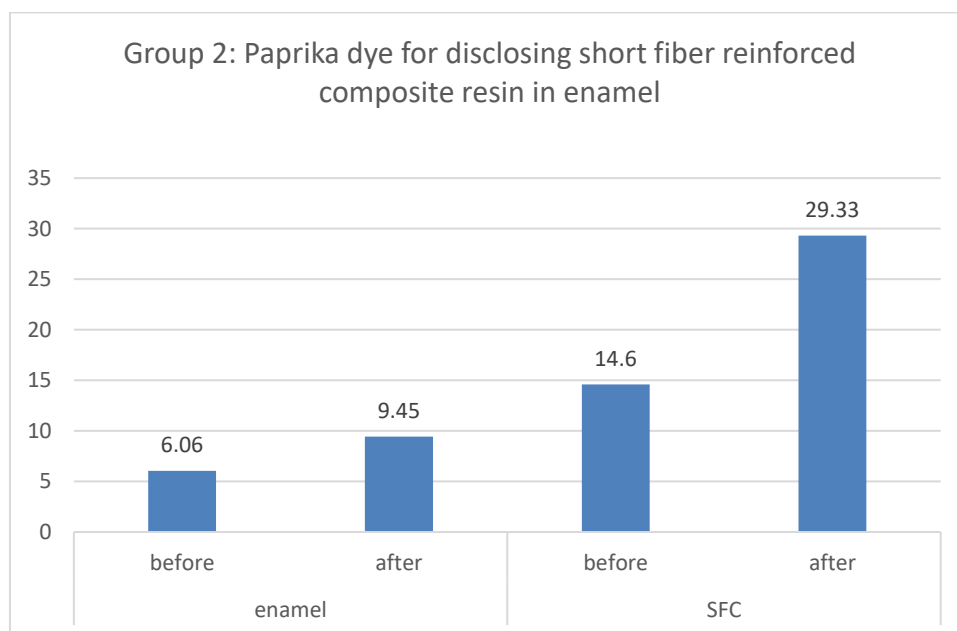


Fig 14: paprika dye for disclosing short fiber reinforced composite resin in enamel

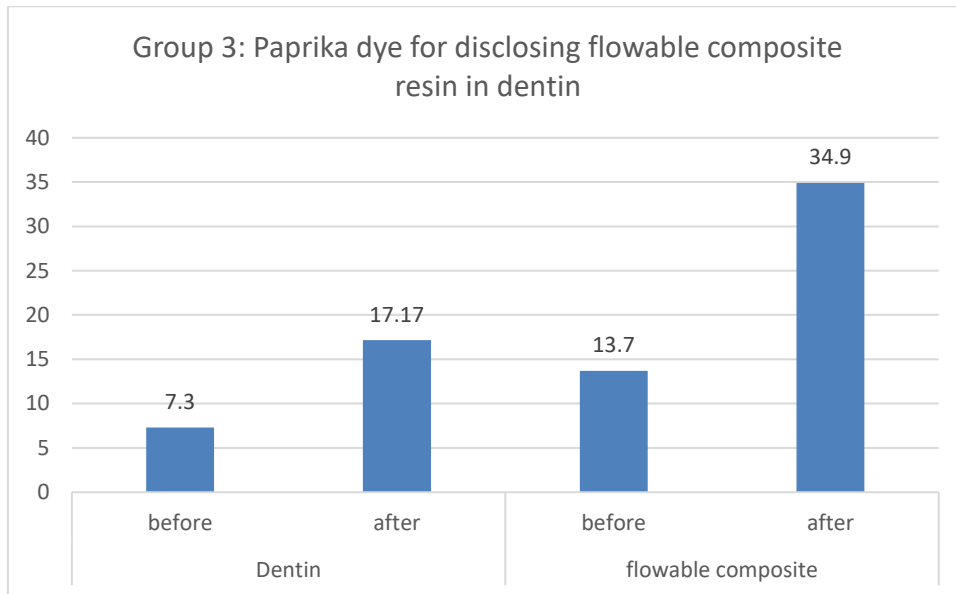


Fig 15: paprika dye for disclosing flowable composite resin in dentin

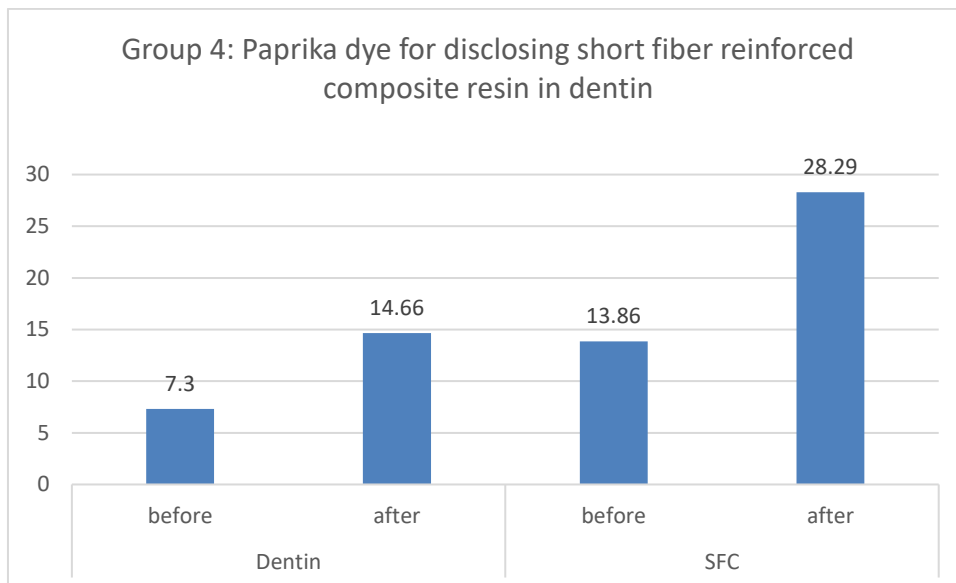


Fig 16: paprika dye for disclosing short fiber reinforced composite resin in dentin

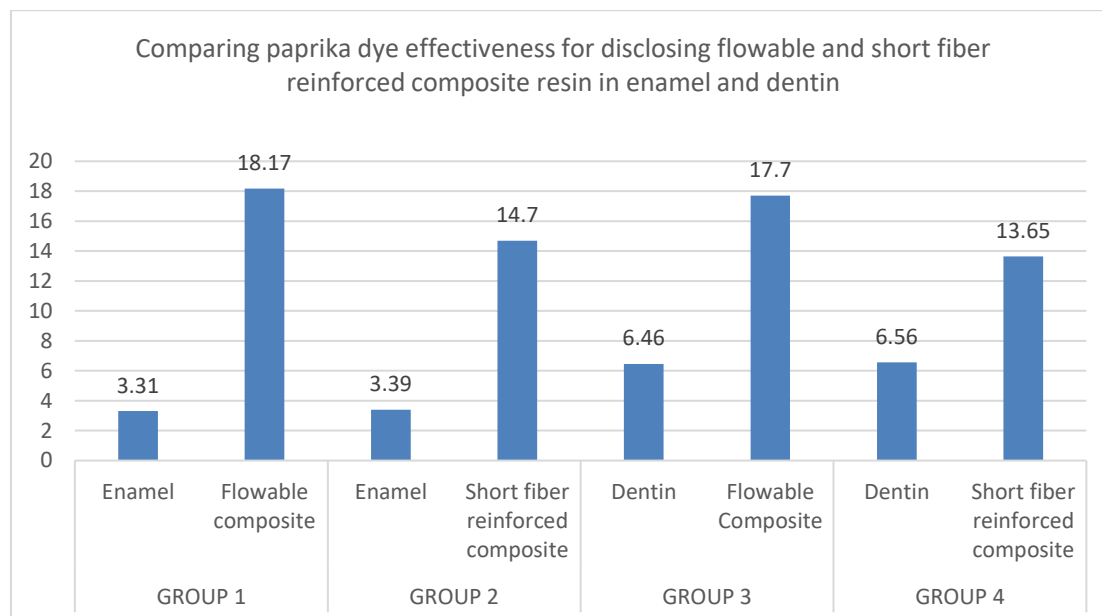


Fig 17: comparing paprika dye effectiveness for disclosing flowable and short fiber reinforced composite resin in enamel and dentin

IV.DISCUSSION

Discoloration, recurrent caries and microleakage causing sensitivity, are among the common reasons for replacing dental composites.¹⁷ The braces are taken off after orthodontic treatment, but some dental composite is still adhered to the tooth structure and needs to be removed. In this era of aesthetic dentistry shade matching is done with precision in restorative dentistry so that composite looks very similar to teeth, its removal can be quite problematic, time consuming and stressful to the dental practitioner during re-restoration and orthodontic debonding procedures.¹⁸

Unable to identify the boundary between teeth and newer advanced composites cause unnecessary removal of tooth structure even with skilled and experienced dentist.¹⁹ A disclosing agent that only stains the composite or stains it more than the tooth would help the dental practitioner identify the boundaries of the composite resin and facilitate its replacement.

Dyes such as brilliant green solution and ink dye have been used in forensic dental identification but these dyes are not FDA approved and are toxic.²⁰ Ultraviolet light (UV), alternative light source and quantitative light-induced fluorescence (QLF) are techniques used to detect the composite resin depending on the different fluorescence properties between composite resin and natural teeth.

Various methods have been used to detect composite resins. Dyes such as 0.2 brilliant green solution and ink dye have been used in forensic dental identification but these dyes are not FDA approved and are toxic.²⁰ Ultraviolet light and alternative light source and quantitative light-induced fluorescence (QLF) techniques which rely on fluorescent properties of composites have limitations like hazardous to human health and need for dark room for detection respectively.²¹

In restorative dentistry, a variety of stains have been used to distinguish the edges of old, disintegrating composite restorations from enamel, including methylene blue, carbol fuchsin, ink dye, brilliant green solution, turmeric in solution or paste form, carmoisine, and erythrosine.²² These are simple affordable and FDA approved.

The staining characteristics of carbol fuchsin, methylene blue, and turmeric using GC Tooth Mousse on composite and tooth surfaces were investigated by Agrawal et al. It was found that methylene blue and carbol fuchsin effectively tinted the composite, but they also discoloured the tooth surface. The tooth surface was barely affected by the turmeric and GC Tooth mousse, however the composite material might become discoloured.²³ Hence a more natural dye which can maximally tint composite with minimal effects on tooth enamel and dentin is needed. Hence, Paprika dye was used in the study.

Desiccated chilli peppers are the primary source of paprika red pigment, a naturally occurring colour. According to research by Abdallah et al, when exposed to hydrophobic substances like paprika, composite resins are more prone to discolouration than tooth surfaces.

β -carotene, capsorubin, and capsanthin are substances responsible for red colour for paprika dye.²⁴ Stainability and antioxidant capability are frequently attributed to polyphenols.²⁵ zebrafish embryo cytotoxicity

research confirmed the nontoxic and effective staining concentration as 1% for paprika-based staining solution for clinical usage.²

The results of the study in Group 1 where Paprika dye used for disclosing flowable composite resin in enamel showed a statistically significant increase in mean dye uptake after composite placement for both enamel and flowable composite resin.

In enamel, the mean ΔE score increased from 6.02 ± 0.18 before to 9.34 ± 0.51 after application, yielding a mean difference of -3.31 , which was significant ($p = 0.000$). Mean score for flowable composite resin in enamel increased from 17.06 ± 0.29 before to 35.23 ± 0.82 after application, yielding a mean difference of -18.17 , which was highly significant ($p = 0.000$).

In Group 2 where Paprika dye used for disclosing short-fiber reinforced composite (SFC) resin in enamel showed an increase in mean ΔE values from 6.06 ± 0.26 before application to 9.45 ± 0.50 after staining, with a mean difference of -3.39 , which was statistically significant ($p = 0.000$). For the SFC composite surfaces, the mean value increased from 14.6 ± 0.30 to 29.33 ± 0.57 , with a mean difference of 14.70 and a significant p -value (0.000).

In Group 3 where Paprika dye used for disclosing flowable composite resin in dentin showed a mean ΔE increase from 7.30 ± 0.32 before to 17.17 ± 0.16 after composite placement (mean difference = -9.87 , $p = 0.000$). The flowable composite resin on dentin demonstrated a larger rise from 13.70 ± 0.63 to 34.90 ± 0.35 , with a mean difference of -21.13 ($p = 0.000$). Finally in Group 4 where Paprika dye used for disclosing short-fiber reinforced composite resin in dentin showed an increase from 7.30 ± 0.30 before to 14.66 ± 0.28 after application, showing a significant difference (mean difference = -7.37 , $p = 0.000$). For the SFC resin, the ΔE values increased from 13.86 ± 0.46 to 28.29 ± 0.49 , with a mean difference of -14.42 , which was statistically significant ($p = 0.00$).

Intergroup comparison across all the four groups, paprika dye consistently showed higher staining scores for flowable composite compared to short-fiber reinforced composite, irrespective of whether the underlying substrate is enamel or dentin. In Enamel Comparisons Group 1 (Flowable composite) showed a Mean value of 18.17 ± 0.59 and Group 2 (SRS composite) showed a Mean value of 14.70 ± 0.48 . Flowable composite exhibited higher staining effectiveness, and the difference between enamel groups was statistically significant ($p = 0.000$). When Dentin Comparisons are made Group 3 (Flowable composite) showed a Mean of 17.70 ± 0.22 and Group 4 (SRS composite) showed a mean of 13.65 ± 0.31 . Again, flowable composite resin showed greater staining intensity than SRS resin on dentin, with highly significant t -values ($p = 0.000$).

In all the groups both flowable and SRS composite showed significant staining with paprika dye compared to enamel and dentine because of the presence of a higher concentration of hydrocarbons in composite resin compared to enamel and dentine. Differential staining affinity of hydrophobic 1% paprika dye toward enamel, dentine and composites can effectively delineate the boundaries between composite and teeth. The enamel outer surface is covered by a carbon-rich layer that plays an important role in extrinsic tooth staining. The fact that composite resin gets stained more with hydrophobic dyes, than outer enamel indicates that composite is more hydrophobic. In this study Paprika stained enamel more than dentine which is significant can be explained by more hydrophobic nature of enamel compared to dentine. So, it can be inferred that 1% paprika dye is more effective in removing flowable and SRS composite restoration in enamel compared to dentine because of the hydrophilicity of dentine which takes less dye.

Hydrophobicity of composite resins is attributed to higher concentrations of carbon than any of the enamel and dentine specimens, and no calcium, phosphate or carbonate ions.

Significant difference was seen between Flowable and SRS composite can be explained difference in composition and filler volume. In this study flowable composite showed significant staining due surface discoloration with paprika dye due to less filler content, subsurface discoloration by mechanical wear during thermocycling and more chemical interaction of dye to matrix compared to densely filled SRS composite.

Flowable composite is selected in the study because of their wide application in restoring enamel defects like cervical abrasions, small occlusal cavities, pit and fissure sealants, repairing provisional or permanent restorations and as liners to reduce polymerisation shrinkage of composites. Flowable composites, which are made to resemble teeth naturally, provide good colour, translucency, and gloss retention.²⁶

The composition of flowable composites—specifically the type of resin matrix and filler system—plays a critical role in determining their optical and mechanical behavior. These properties are essential for maintaining the esthetics and longevity of restorations. In clinical service, challenges arise from dynamic oral conditions such as temperature fluctuations, dietary habits, and aging. These factors can degrade the composite's surface and optical properties over time, potentially requiring interventions like repolishing or replacement.

Ever-X Posterior (GC, Tokyo, Japan) is a short fiber reinforced composite E Glass fiber filler type with 74.2% filler volume.²⁷ E glass fibers are embedded in a Bis-GMA, TEGDMA, and PMMA matrix. The short fibers enhance the mechanical properties by functioning principally as crack blocker, preventing crack initiation and propagation. They reduce microleakage by decreasing polymerization shrinkage by their fiber orientation.²⁸ Ever X Posterior was chosen because Tsujimoto et al. in his study concluded EverX Posterior exhibited the lowest

volumetric shrinkage compared to other bulk fill composites.²⁹ 7.1% of SFRC restorations and 10.7% of micro-hybrid resin composite restorations showed slight colour changes after three years and needs replacement. Hence SRFC composites are used in the study as limited literature is available to disclose SRFC composite by paprika dye. Bis-GMA matrix of eXP may have an impact on greater ΔE_{00} values during the staining process along with to its fiber-reinforced structure.³⁰

Spectrophotometers measure colour objectively by measuring Mean colour change (ΔE), which measures variations in $L^*a^*b^*$ coordinates between specimens. ΔE^* value between 0 and 2 indicates insignificant differences, ΔE^* value of 3.7 or below is considered clinically appropriate, whereas values greater than 5 suggest the need for restorative replacement. Spectrophotometer instruments are chosen for measuring colour parameters due to their precision in measuring colour by analysing the wavelengths reflected or transmitted.³¹

In this study, the standardized box shaped cavity were made in enamel and dentin. Stress contraction due to C-factors, extensive cavities, composite resin application technique, light intensity, positions were avoided among the groups.

Since 8% externally caused discolouration can be linked to surface roughness, surface integrity, and the polishing method, all of the samples are polished and completed. Surface flaws created due to imperfections in filler particle sizes during finishing procedures might also have contributed to significant staining of flowable composite compared to SRFC.

Thermocycling test was regarded as the most frequently used method to simulate thermal changes and hydrolytic activities in the intraoral environment, which tested bond durability of the tooth-restoration. Gale et al. estimated that 10,000 cycles represented 1 year of service. Adequate thermocycling was done in the study to simulate the aging in intra oral conditions.³²

In conclusion 1% Paprika is a naturally effective dye in disclosing failed composite restorations in enamel and dentine substrates. The limitations of this study is usage of only two different types of composites. This is an invitro study with limited samples size. The surfaces of the samples made for this investigation were flat. In therapeutic settings, uneven polishing is caused by pits and grooves. Therefore, long-term in vivo research is required to evaluate the composites' colour stability. Other factors include the varying surface textures and anatomical differences in natural teeth. The enamel layering over dentin and the different levels of translucency in natural teeth can also pose challenges.³³

V.CONCLUSION

The following conclusions can be drawn from the current study:

Over all in the present study, paprika dye effectively stained flowable and short fiber reinforced composite in enamel and dentin substrates.

1. Regarding the Mean percentage of staining ability by paprika dye in enamel and dentin, flowable composite and short fiber reinforced composite showed statistically significant difference.
2. Flowable composite showed more staining with the dye compared to short fiber reinforced composite.
3. Flowable composite showed more staining in enamel compared to dentin which is statistically significant.
4. Statistically significant difference is seen with enamel and dentin substrates with paprika dye. Spectrophotometric changes were more in enamel compared to dentin.
5. Regardless of type of composite both flowable and fiber reinforced composites showed significant difference with enamel and dentin by spectrophotometric analysis.

To Conclude paprika dye is effective in staining flowable and short fiber reinforced composites in underlying enamel and dentin substrates. Further in vivo research is required to strengthen these findings.

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