Frontiers in Dentistry

Effect of Tea on Color Stability of Enamel Lesions Treated with Resin Infiltrant

Mansoureh Emami Arjomand[1], Maryam Hoorizad Ganjkar[2], Roshanak Ghamari[1*]

1. Department of Operative Dentistry, Islamic Azad University, Dental Branch, Tehran, Iran
2. Department of Operative Dentistry, Member of Dental Material Research Center, Islamic Azad University, Dental Branch, Tehran, Iran

Article Info

Article type:
Original Article

Article History:
Received: 14 Apr 2020
Accepted: 23 Nov 2020
Published: 26 Jan 2021

**** Corresponding author:***
Department of Operative Dentistry, Islamic Azad University, Dental Branch, Tehran, Iran

Email: roshanak.ghamari71@gmail.com

A B S T R A C T

Objectives: This study aimed to assess the effect of tea on color stability of enamel lesions treated with resin infiltrant (RI).

Materials and Methods: This in vitro, experimental study evaluated 30 extracted human third molars with no caries, cracks, or enamel defects. Enamel-dentin samples measuring 5 x 5 x 3 mm were prepared from the buccal surfaces of the teeth by a microtome. The samples were divided into three groups of 10 namely sound enamel, demineralized enamel, and demineralized enamel plus RI. White spot lesions (WSLs) were artificially created by immersing the samples in hydroxyethyl cellulose demineralizing gel with a pH of 4.5 for 4 days. Next, Icon RI was applied on the samples in group 3. The baseline color of the samples was measured using a spectrophotometer. They were immersed in tea solution 3 times a day, each time for 15 min, for a period of 2 weeks and then underwent colorimetry again. Data were analyzed using one-way ANOVA.

Results: The maximum color change (ΔE) was noted in demineralized enamel plus RI group (38.59±6.13) with significant differences with sound enamel (20.00±2.94) and demineralized enamel (25.27±7.47) groups ($P<0.05$). The difference between the latter two groups was not significant ($P>0.05$).

Conclusion: Within the limitations of this in vitro study, the results showed that tea solution caused clinically unacceptable color change in all groups. However, the color stability of WSLs treated with RI was significantly lower than other groups following immersion in tea solution.

Keywords: Spectrophotometry; Dental Enamel; Dental Caries

- **Cite this article as:** Emami Arjomand M, Hoorizad Ganjkar M, Ghamari R. In Vitro Bacterial Leakage at the Implant-Abutment Connection of Two Dental Implant Systems with Internal Connection. Front Dent. 2021:18:4. doi: 10.18502/fid.v18i4.5434

INTRODUCTION

White spot lesions (WSLs) are opaque chalky-white lesions as the first clinical appearance of dental caries. WSLs often develop in orthodontic patients with poor oral hygiene under or around orthodontic brackets and in patients who use an orthodontic appliance for a long period of time. These areas of demineralized enamel are only detected when dry [1].

Fixed orthodontic treatment enhances plaque retention and accumulation around orthodontic brackets, under the orthodontic wires, and below the gingival margin. Thus, orthodontic treatment is believed to increase the risk of enamel demineralization and development of WSLs [2]. WSLs can progress into carious lesions and compromise the esthetic appearance of the teeth [3]. Therefore, WSLs should be treated promptly to prevent caries and improve esthetics [4]. Since enamel cavitation is not present in WSLs, improving the oral hygiene combined with non-invasive treatment procedures such as fluoride therapy and application of casein phosphopeptide amorphous calcium phosphate are often recommended for their management. However, even if the progression of carious lesions is ceased, the unesthetic chalky white appearance of the lesions remains [5,6].

Recently, a new technique was suggested for management of WSLs, which involved the application of resin infiltrant (RI). In this technique, known as resin infiltration, a low-viscosity resin is applied over the WSLs, which penetrates into the lesions according to the infiltration phenomenon and prevents the progression of caries. Since the refraction coefficient of RI is similar to that of hydroxyapatite, it masks the chalky white appearance of WSLs and improves esthetics [7-9]. However, some concerns exist regarding the color change of RI over time, since some colored foods and drinks such as tea and coffee may cause discoloration of its resin matrix [10]. Accordingly, a question arises whether enamel lesions treated with RI experience a color change similar to that of sound enamel when exposed to coloring agents. Considering the gap of information on this topic, this study aimed to assess the effect of tea on color stability of enamel lesions treated with RI.

MATERIALS AND METHODS

In this in vitro, experimental study, 30 extracted human third molars were collected and immersed in 0.1% thymol solution at room temperature. The teeth with caries, cracks or enamel defects were excluded and replaced with sound teeth. The study protocol was approved by the ethics committee of Islamic Azad University, Dental Branch Tehran, Iran (IR.IAU.DENTAL.REC.1399.205).

Sample size was calculated to be 10 in each of the three groups according to a study by Araujo et al, [11] assuming alpha=0.05, beta=0.2, standard deviation of 3.41, and effect size of 0.49 using two-sample t-test.

The teeth were collected by targeted sampling.

Enamel-dentin samples measuring 5 x 5 x 3 mm were prepared from the buccal surfaces of the teeth by a microtome (Presi, France). The enamel surface was then polished with 800, 1200, and 2400-grit Sof-Lex discs (3M ESPE, St. Paul, MN, USA). The dentin surface was coated with two layers of nail varnish. The samples were then mounted in silicon molds, which were filled with auto-polymerizing acrylic resin [12], and randomly divided into three groups (n=10) of sound enamel (group 1), demineralized enamel (group 2), and demineralized enamel plus RI (group 3). The samples in the sound enamel group were stored in artificial saliva (pH=7) [13] during the entire course of the study. In groups 2 and 3, WSLs were artificially induced by immersing the samples in a demineralizing gel made of hydroxyethyl cellulose with a pH of 4.5 for 4 days at 37°C according to the method described by Ameachi et al [14]. In demineralized enamel group, artificially demineralized samples were immersed in artificial saliva while in group 3, artificially created WSLs underwent treatment with Icon RI (DMG, Hamburg, Germany) according to the manufacturer's instructions. For this purpose, the surface of the specimens was first cleaned. Then, Icon Etch containing 15% HCl (DMG, Hamburg, Germany) was applied for 2 min to create surface porosities. The samples were then rinsed with water for 30 s and dried with air stream. Next, Icon Dry containing 99% ethanol (DMG, Hamburg, Germany) was applied for 30 s and spread with air stream. Icon Infiltrant (DMG, Hamburg, Germany) was then applied for 3 min and light-cured for 40 s using a LED curing unit (Coltene, Langenau, Germany) with a light intensity of 1000 mW/cm^2. Another coat of Icon Infiltrant was applied for 1 min and cured [12]. Table 1 summarizes the procedural steps of application of Icon Caries Infiltrant. The samples were then immersed in artificial saliva for 24 h. The primary color of the samples was determined by a spectrophotometer (X-rite CI 6X; Grand Rapids, MI, USA) according to the CIE L*a*b* color space. The samples were immersed in 200 mL of 37°C tea solution (Lipton, England) for 2 min [15,16]. This process was repeated for 15 min 3 times a day for 2 weeks.

Table 1. Characteristics and application method of Icon Caries Infiltrant

Material	Icon® caries Infiltrant
Manufacturer	DMG, Hamburg, Germany
Composition	1- Icon, Etch (HCL 15%) 2- Icon Dry (99% ethanol) 3- Icon Infiltrant (methacrylate-based resin matrix, initiators, additives)
Direction of usage	1-Clean tooth 2-Apply Icon – Etch. Let set for 2 min 3-Rinse off with water for 30 s. Air dry 4-Apply Icon Dry. Let set for 30 s. Air dry 5- Apply Icon Infiltrant. Let set for 3 min 6- Light-cure for 40 s 7- Apply Icon Infiltrant. Let set for 1 min 8- Light-cure for 40 s

Colorimetry was then performed again [11]. Data were analyzed using one-way ANOVA.

RESULTS

Table 2 shows the mean, standard deviation, minimum and maximum values of color parameters of the three groups. Table 3 shows the color change (ΔE) of the groups following immersion in tea solution. The difference in ΔE among the groups was statistically significant ($P<0.05$). Maximum ΔE was noted in group 3 (demineralized enamel plus RI) with significant differences with sound enamel ($P=0.000$), and demineralized enamel ($P=0.000$) groups. However, the difference between the latter two groups was not significant ($P=0.126$).

DISCUSSION

This in vitro study assessed the effect of tea on color stability of enamel lesions treated with RI. The results showed maximum ΔE in demineralized enamel plus RI group with significant differences with sound enamel (20.00±2.94) and demineralized enamel (25.27±7.47) groups ($P<0.05$). The difference between the latter two groups was not significant ($P>0.05$).

When applied for treatment of WSLs, RI prevents the progression of caries, fills the porosities, and corrects the refraction coefficient of light, creating an esthetic appearance. However, RI is susceptible to color change, similar to other resin materials. The severity of this discoloration may vary depending on the patients' nutritional habits and oral hygiene [17].

Tea is a commonly consumed drink worldwide, and particularly in Iran. It is commonly used as a coloring agent to assess the color stability of materials in vitro. It has high potential for staining of tooth structure and resin-based dental restorative materials [18]. Water sorption and solubility are important factors affecting the stainability and color stability of polymer materials, which are related to the structure of resin matrix. Water sorption and absorption of liquids by the organic phase of polymers can result in degradation of organic phase and its subsequent discoloration [19]. Moreover, inhibition of polymerization by oxygen and shrinkage due to the presence of resin can cause non-homogenous areas, which can accelerate the penetration and accumulation of stains and their adsorption [19].

Table 2. Mean, standard deviation, minimum and maximum values of color parameters in the three groups

Group	Minimum			Maximum			Mean± std. deviation		
	ΔL	Δa	Δb	ΔL	Δa	Δb	ΔL	Δa	Δb
Sound enamel	-24.50	1.7	2.5	16.47-	3.93	5.21	19.49±2.9	2.65±0.79	3.5±0.92
Demineralized enamel	-38.14	3.89	-1.4	-15.24	7.16	7.58	-24.15± 7.56	5.51± 1.04	3.76±3.13
Resin infiltrant	-48.39	3.4	4.15	-25.06	9.02	10.85	-37.39±6.01	5.76±1.97	7.24±1.83

Table 3. Mean±standard deviation (SD), maximum (Max) and minimum (Min) color change in the three groups

Groups	Min	Max	Mean±SD
Sound enamel	16.83	25.11	20.01 ±2.94
Demineralized enamel	16.43	38.42	25.27 ±7.47
Resin infiltrant	26.01	49.78	38.59 ±6.13

TEGDMA monomer is present in the composition of RI with no filler particles [20]. Evidence shows that TEGDMA is a hydrophilic monomer with high water sorption compared with other resin monomers. Thus, Icon can easily absorb stains present in colored foods and drinks such as tea [20, 21]. Brown discoloration noticed following tea consumption can be attributed to adsorption and penetration of tea stains into the resin polymer network [21].

In the present study, tea solution caused a significant color change in all three groups, which was in agreement with the findings of Borges et al [13], Araujo et al, [11] and Zhao and Ren [22]. This color change was associated with a reduction in L* parameter and an increase in a* and b* parameters. The samples immersed in tea showed a yellowish and grayish appearance. Statistical analysis showed that ΔE experienced the greatest change, which was in agreement with the results of Araujo et al [11]. They assessed the effect of immersion in coffee solution on color stability of RI for 14 days and observed that immersion in coffee caused significant color change of RI (ΔE=21.33). The ΔL parameter in their study showed maximum change [11]. However, Borges et al. [13] indicated that the a* and b* color parameters experienced maximum change. This difference between their results and ours may be due to the use of different coloring solutions since Borges et al. [13] used red wine as the coloring agent while we used tea. Similar to our study, they demonstrated that ΔE following immersion was significant and exceeded the clinically acceptable threshold.

The current results and those of Zhao and Ren [22] and Leland et al. [10] demonstrated that the color change of RI is due to the adsorption of stains into the surface and mass structure of material. Future studies are required to assess the efficacy of polishing for reduction of color change of WSLs treated with RI.

CONCLUSION

Tea solution caused a significant, clinically unacceptable color change in all groups (ΔE>3.3). The color stability of resin infiltrated WSLs was significantly lower than that of sound enamel and demineralized enamel when exposed to tea solution.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Ritter AV, Heymann HO, Swift EJ. Sturdevant's art and science of operative dentistry. St Louis: Mosby, 2013:41-88.
2. Ahmed I, Saif-ul-Haque, Nazir R. Carious lesions in patients undergoing orthodontic treatment. J Pak Med Assoc. 2011 Dec;61(12):1176-9.
3. Kidd EA, Fejerskov O. What constitutes dental caries? Histopathology of carious enamel and dentin related to the action of cariogenic biofilms. J Dent Res. 2004 Jul;83(1_suppl):35-8.
4. Gugnani N, Pandit IK, Gupta M, Josan R. Caries infiltration of noncavitated white spot lesions: A novel approach for immediate esthetic improvement. Contemp Clin Dent. 2012 Sep;3(Suppl 2):S199.
5. Staudt CB, Lussi A, Jacquet J, Kiliaridis S. White spot lesions around brackets: in vitro detection by laser fluorescence. Eur J Oral Sci. 2004 Jun;112(3):237-43.
6. Mattousch TJ, Van Der Veen MH, Zentner A. Caries lesions after orthodontic treatment followed by quantitative light-induced fluorescence: a 2-year follow-up. Eur J Orthod. 2007 Jun;29(3):294-8.
7. Paris S, Meyer-Lueckel H. Masking of labial enamel white spot lesions by resin infiltration--A clinical report. Quintessence Int. 2009 Oct;40(9):713-8.
8. Paris S, Schwendicke F, Keltsch J, Dörfer C, Meyer-Lueckel H. Masking of white spot lesions by resin infiltration in vitro. J Dent. 2013 Nov;41 Suppl 5:e28-34.

9. Torres CR, Borges AB, Torres LM, Gomes IS, de Oliveira RS. Effect of caries infiltration technique and fluoride therapy on the color masking of white spot lesions. J Dent. 2011 Mar;39(3):202-7.
10. Leland A, Akyalcin S, English JD, Tufekci E, Paravina R. Evaluation of staining and color changes of a resin infiltration system. Angle Orthod. 2016 Nov;86(6):900-4.
11. Araújo GS, Naufel FS, Alonso RC, Lima DA, Puppin-Rontani RM. Influence of staining solution and bleaching on color stability of resin used for caries infiltration. Oper Dent. 2015 Nov-Dec;40(6):E250-6.
12. Cohen- Carneiro F, Pascareli AM, Christino MR, Vale HF, Pontes DG. Color stability of carious incipient lesions located in enamel and treated with resin infiltration or remineralization. Int J Paediatr Dent. 2014 Jul;24(4):277-85.
13. Borges AB, Caneppele TM, Luz M, Pucci CR, Torres CR. Color stability of resin used for caries infiltration after exposure to different staining solutions. Oper Dent. 2014 Jul-Aug;39(4):433-40.
14. Amaechi BT, Higham SM, Edgar WM. Factors affecting the development of carious lesions in bovine teeth in vitro. Arch Oral Biol. 1998 Aug;43(8):619-28.
15. Mundim FM, Garcia LD, Pires-de-Souza FD. Effect of staining solutions and repolishing on color stability of direct composites. J Appl Oral Sci. 2010 May-Jun;18(3):249-54.
16. Ertas E, Gueler AU, Yuecel AC, Koepruelue H, Gueler E. Color stability of resin composites after immersion in different drinks. Dent Mater J. 2006 Jun;25(2):371-6.
17. Topcu FT, Sahinkesen G, Yamanel K, Erdemir U, Oktay EA, Ersahan S. Influence of different drinks on the color stability of dental resin composites. Eur J Dent. 2009 Jan;3(1):50-6.
18. Park JK, Kim TH, Ko CC, Garcia-Godoy F, Kim HI, Kwon YH. Effect of staining solutions on discoloration of resin nanocomposites. Am J Dent. 2010 Feb;23(1):39-42.
19. Bagheri R, Burrow MF, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. J Dent. 2005 May;33(5):389-98.
20. Paris S, Meyer-Lueckel H, Kielbassa AM. Resin infiltration of natural caries lesions. J Dent Res. 2007 Jul;86(7):662-6.
21. Sideridou ID, Karabela MM, Bikiaris DN. Aging studies of light cured dimethacrylate-based dental resins and a resin composite in water or ethanol/water. Dent Mater. 2007 Sep;23(9):1142-9.
22. Zhao X, Ren YF. Surface properties and color stability of resin-infiltrated enamel lesions. Oper Dent. 2016 Nov;41(6):617-26.