DOI: http://doi.org/10.54617/adoklinikbilimler.1135082

Original Research Article

Application of Resin Infiltration Technique in the Treatment of Tooth Surface Losses Due to Erosion: *In vitro* Study

Erozyona Bağlı Diş Yüzeyi Kayıplarında Rezin İnfiltrasyon Tekniği Uygulanması: İn vitro Çalışma

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ABSTRACT

Aim: The aim of this study was to evaluate the efficiency of the resin infiltration technique on the eroded enamel surface of both primary and permanent teeth using a DIAGNOdent pen and CIE L*a*b values.

Materials and Method: Buccal surfaces of 28 permanent and 28 primary teeth were covered with nail polish leaving an area of 2*2mm width*height and kept in orange juice for 4 days as a part of the erosion cycle. Then, a resin infiltration agent (ICON, DMG, Hamburg, Germany) was applied to all of the teeth. Within the scope of this study, pre-erosion, post-erosion and post-treatment measurements were made before erosion, after erosion and after resin infiltration application with a fluorescent-based device and CIE L*a*b values. CIE L*a*b values were analyzed using paired T-test and ΔLab values were compared with Wilcoxon Signed Rank Test. The statistical significance level was $p<0.05$.

Results: The results of the fluorescence-based device were statistically significant for both primary and permanent teeth for pre-erosion, post-erosion, and post-treatment results ($p<0.05$). The ΔLab values were statistically significant for both primary ($p=0.04$, $p<0.05$) and permanent ($p=0.01$, $p<0.05$) teeth.

Conclusion: The results of the present study showed the masking ability of the resin infiltration technique using DIAGNOdent pen and CIE L*a*b values. Accordingly, resin infiltration might be a solution to mask erosion lesions in permanent and primary teeth and provide aesthetic expectations depending on aesthetic requirements.

Keywords: Masking; Resin infiltration technique; Tooth erosion

ÖZET

Amaç: Süt ve daimi dişlerde erozyona uğramış mine yüzeylerinde rezin infiltrasyon tekniğinin etkinliğini DIAGNOdent kalemi ve CIE L*a*b değerleri ile değerlendirilmesidir.

Gereç ve Yöntem: Çalışma sırasında 28 daimi ve 28 süt dişin bukkal yüzeyleri 2*2mm genişlik*yükseklikte alan açıkta kalacak şekilde oje ile kaplanmış ve erozyon döngüsü kapsamında 4 gün portakal suyunda bekletilmiştir. Daha sonra tüm dişlere rezin infiltrasyon ajanı (ICON, DMG, Hamburg, Almanya) uygulanmıştır. Çalışma kapsamında erozyon öncesi, erozyon sonrası ve tedavi sonrası ölçümleri yapılarak lazer floresan kalem ve CIE L*a*b değerleri karşılaştırılmıştır. Erozyon öncesi, erozyon sonrası ve işlem sonrası için CIE L*a*b değerleri eşleştirilmiş T-testi, ΔLab değerleri Wilcoxon Signed Rank Test ile karşılaştırılmış ve istatistiksel anlamlılık düzeyi $p<0.05$ kabul edilmiştir.

Bulgular: Süt ve daimi dişler için erozyon öncesi, erozyon sonrası ve tedavi sonrası lazer floresan bazlı kalem değerleri istatistiksel olarak anlamlı fark göstermiştir ($p<0.05$). Ayrıca, ΔLab değerleri de hem süt ($p=0.04$, $p<0.05$) hem daimi dişler ($p=0.01$, $p<0.05$) için istatistiksel olarak anlamlı fark göstermiştir.

Sonuç: Bu çalışmanın sonuçları, DIAGNOdent kalemi ve CIE L*a*b değerleri ile ölçüm yaparak erozyon durumunda rezin infiltrasyon tekniğinin maskeleme yapabildiği gösterilmiştir. Bu nedenle daimi ve süt dişlerinde estetik kaygıya neden olan erozyon lezyonlarının maskelenmesinde estetik beklentiyi karşılamak için rezin infiltrasyon tekniği bir çözüm olabilir.

Anahtar Kelimeler: Diş erozyonu; Maskeleme; Rezin infiltrasyon tekniği

Makale gönderiliş tarihi: 23.06.2022; Yayına kabul tarihi: 17.06.2023

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INTRODUCTION

Dental erosions occur because of a chain of events that are similar to the destruction mechanism of non-cavitated caries lesions, also known as white spot lesions. Erosive surface losses that develop on the tooth surface can be observed in both primary and permanent teeth and generally develop due to diet, drug use, and other harmful habits.[1] The most common reason for tooth demineralization and surface loss in the form of erosion is the excessive consumption of acidic beverages.[2]

Typically, the surface layer of the affected enamel remains intact with a localized mineral loss on the tooth surfaces that, if not controlled over time, will eventually lead to cavitation on the enamel surface. However, enamel has a unique capacity for naturally repairing non-cavitated lesions.[3] Lesions that are diagnosed in a non-cavitated state can be treated by improving oral hygiene and recommending the application of protective and preventive agents. However, if these dietary and oral hygiene recommendations are not followed, destruction of the enamel's surface will continue, and the onset of cavitation is likely to occur within 48-72 hours.[4]

In recent years, a new approach has been developed to prevent non-cavitation enamel lesions from progressing, particularly for anterior teeth, where esthetic concerns might be involved. The basis of this new treatment approach is the removal of the affected enamel surface through the application of hydrochloric acid and the penetration of low-viscosity resin-containing material onto this supposedly intact surface.[5,6] In this context, ICON (DMG, Resin Infiltration System, Hamburg, Germany) is the best known and has a successful prognosis compared with other materials based on many case reports, *in vitro* and *in vivo* studies.[7-14]

Despite the presence of studies[9-14] on the resin infiltration technique involving non-cavitated caries lesions, there is a lack of data on the effect of this technique against dental erosion in the literature. Therefore, the aim of this study was to evaluate the efficiency of the resin infiltration technique on the enamel surface of both primary and permanent teeth following erosion measurements with a DIAGNOdent pen and CIE L*a*b values obtained from photographs. This study was based on the hypotheses that (1) the resin infiltration technique would mask erosive lesions and (2) the quantitative values obtained from the DIAGNOdent measurements and CIE L*a*b values obtained from photographs would yield similar results.

MATERIALS AND METHOD

The sample size of each group was calculated for primary outcome measures according to the data obtained from articles[7,15,17] that evaluated the color masking method. Accordingly, 28 samples were included per group for primary and permanent teeth, and three repeated measurements were used to detect a significant difference for a two-sided type I error at 5% and 90% power.

Primary molar teeth extracted due to the spontaneous eruption of permanent teeth, and impacted permanent third molars with extraction indication were collected from healthy patients with no systemic diseases. This study was approved by Başkent University Institutional Review Board and Ethics Committee with protocol no: D-KA 22/17 All of the collected samples were included in the study within 6 months after receiving parents' informed consent. Primary molar teeth with any restoration, caries, discoloration, or hypomineralized areas on enamel surfaces were excluded.

Experimental Procedure

All permanent and primary teeth included in this study were embedded in acrylic blocks (Paladur®, Bad Homburg, Germany) and covered with nail polish leaving an area of 2*2mm width*height on the buccal surface. During the study procedure, all teeth were kept in orange juice (pH: 3.9) for 4 days as part of the erosion cycle; then, a resin infiltration agent (ICON, DMG, Hamburg, Germany) was applied to all teeth according to the manufacturer's instructions. In the first step, a 15 % hydrochloric acid gel (ICON-Etch) was applied to the surface of the lesion for 2 min and then water rinsed and air dried for 30 s, followed by the application of ethanol (ICON-Dry) for 30 s and additional air drying. The low-viscosity resin infiltrant (ICON-Infiltrant) was applied to the surface for 3 min and light cured for 40 s. For this study, three measurements were made under the headings 'pre-erosion', 'post-erosion' and 'post-treatment' stage within the scope of the erosion cycle.

Surface Analyses Methods

All the teeth were measured three times using the fluorescence-based device (DIAGNOdent pen 2190, KaVo Dental GmbH, Biberach, Germany) to analyze surface changes due to the orange juice or resin infiltration agent. The mean value of these three values was compared to derive the differences between the pre-erosion, post-erosion, and post-treatment stages. Colorimetric analysis was completed using the CIE L*a*b values obtained from photographs to determine the masking ability of resin infiltration after erosion. Similar to fluorescence-based device measurements, CIE L*a*b values were measured three times to obtain a mean value and compare the colorimetric differences between the pre-erosion, post-erosion, and post-treatment stages. The CIE-L*a*b* color system was used to analyze the optical results. The system records colorimetric parameters three-dimensionally i.e., lightness (L*; 0 to + 100), green-red chromaticity (a*; − 150 to + 100), and blue-yellow chromaticity (b*; −100 to + 150).

Surface and colorimetric analyses were evaluated separately for all primary and permanent teeth within the scope of this study. Surface analyses were conducted according to the results of the fluorescence-based device for pre-erosion, post-erosion and post-treatment stages using a pairwise comparison. Colorimetric analyses were conducted by determining the mean CIE L*a*b values for each stage and comparing them with one another. However, the results of the colorimetric analyses between pre-erosion and post-erosion, and post-erosion and post-treatment were given as ΔLab values to compare the efficacy of the resin infiltration technique for treating erosion.

Statistical Analysis

Descriptive statistics were given as the mean, standard deviation, minimum and maximum L*a*b values for the pre-erosion, post-erosion, and post-treatment stages for primary and permanent teeth. The statistical differences between the L*a*b values for pre-erosion, post-erosion, and post-treatment stages for primary and permanent teeth were analyzed using a paired samples T-test. The ΔLab values were compared using Related Samples Wilcoxon Signed Rank Test to analyze the statistical differences between pre-erosion and post-erosion, and post-erosion and post-treatment. The statistical significance level was $p<0.05$.

RESULTS

The results of the pre-erosion, post-erosion, and post-treatment measurements for primary and permanent teeth made using the fluorescence-based device is shown in Table 1. According to the results of the statistical analysis, the surface changes measured with the fluorescence-based device were statistically significant, with $p<0.05$ between pairwise measurements for the pre-erosion, post-erosion, and post-treatment stages.

The CIE L*a*b values are given in mean, standard deviation, minimum and maximum values in Table 2, and the statistical differences were analyzed between pre-erosion, post-erosion, and post-treatment stage measurements. According to the obtained data, there were statistical differences between the CIE L*a values of pre-erosion, post-erosion, as well as the post-treatment stages for both primary and permanent teeth ($p<0.05$). However, there was no statistical difference between pre-erosion and post-treatment CIE b values for primary teeth with a value of $p=0.06$; there was a statistical difference between post-erosion and post-treatment and pre-erosion and post-erosion CIE b values for primary teeth ($p<0.05$). Pre-erosion, post-erosion and post-treatment CIE b values for permanent teeth indicated a statistical difference in the pairwise comparison ($p<0.05$).

The ΔLab values were determined using the measurements between the pre-erosion and post-erosion stages to determine the statistical difference in erosion efficacy and between post-erosion and post-treatment to derive the statistical difference in the efficacy of the resin infiltration technique. According to the results given in Table 3, the analysis of ΔLab values for the erosion and resin infiltration technique shows a statistically significant difference for both primary ($p=0.04$; $p<0.05$) and permanent teeth ($p=0.01$, $p<0.05$).

Table 1. Surface analysis with DIAGNOdent pen results for pre-erosion, post-erosion, and post-treatment of primary and permanent teeth

	Pre-erosion		Post-erosion		Post-treatment	
	Mean±sd	**95% CI Min-Max**	**Mean±sd**	**95% CI Min-Max**	**Mean±sd**	**95% CI Min-Max**
Primary teeth	3.84±5.03[a,c]	1.0-25.7	14.62±11.15[a,b]	5.0-64.7	6.94±3.12[b,c]	4.3-20.0
Permanent teeth	1.39±0.58[d,f]	0.3-3.0	13.14±12.19[d,e]	4.7-63.3	6.2±1.5[e,f]	3.0-10.7

*sd: Standard deviation; Min: Minimum; Max: Maximum; CI: 95% Confidence Interval of the Difference; Same superscript letters show the statistical significance between pairwise measurements; Significance level at p<0.05.

Table 2. Relationship between L*a*b values of pre-erosion, post-erosion, and post-treatment for primary and permanent teeth

		Pre-erosion		Post-erosion		Post-treatment	
		Mean±sd	**95% CI Min-Max**	**Mean±sd**	**95% CI Min-Max**	**Mean±sd**	**95% CI Min-Max**
Primary teeth	**L**	78.99±5.48[a,d]	67-89	96.98±2.74[a,f]	86-100	76.8±5.91[d,f]	65-89
	a	11.5±7.05[b,e]	0-32	-1.99±3.045[b,g]	-9-9	16.6±5.7[e,g]	5-34
	b	18.02±7.95[c]	1-48	1.02±3.1[c,h]	-4-14	16.33±6.13[h]	6-32
Permanent teeth	**L**	69.86±6.74[i,l]	52-82	96.24±3.27[i,o]	86-100	64.31±7.38[l,o]	28-80
	a	18.81±6.1[j,m]	3-34	-1.33±3.78[j,p]	-7-12	23.07±6.47[m,p]	10-38
	b	15.17±8.09[k,n]	2-39	0.05±3.88[k,r]	-21-15	18.19±6.64[n,r]	5-37

*Lower superscript letters state statistical significance; p<0.05; Difference between pre-erosion and post-treatment b values for primary teeth did not show statistical significance with a value of 0.06.

Table 3. Relationship between ΔLab values of pre-erosion and post-erosion, and post-erosion and post-treatment for primary and permanent teeth

	ΔLab (Pre-erosion – Post-erosion)		ΔLab (Post-erosion – Post-treatment)		
	Mean±sd	**95% CI Min-Max**	**Mean±sd**	**95% CI Min-Max**	**P value**
Primary Teeth	28.98±5.12	19.9-40.73	32.13±6.66	19.86-45.28	0.04
Permanent Teeth	37.02±6.67	27.1-57.3	44.68±6.51	28.6-58.5	0.01

*Significance level was p<0.05.

DISCUSSION

The resin infiltration technique is one of the current treatment methods of the first stages of caries lesions without cavitation. With the application of this system on tooth enamel surfaces where cavitation has not yet occurred, the pores on the initial surface are clogged and acid-mineral transitions are reduced. In this way, the progression of the lesion is prevented, and the progression of caries is slowed down or even stopped. Furthermore, the color of the enamel surface can potentially be masked to regain esthetic appeal.[14,15] To the best of our knowledge, no existing articles indicate this particular point for erosion lesions. Therefore, the aim of the present study was to evaluate the efficiency of the resin infiltration technique in cases of erosive enamel loss for primary and permanent teeth.

Articles applying both *in vitro* and *in-vivo* approaches[7-14] have evaluated the efficacy of the resin infiltration system for treating white spot lesions. It has been suggested that this approach reduces microporosity, supports tissue mechanically, and traps microorganisms that potentially cause caries to the sublayers of the caries lesion while at the same time depriving them of nutritional support.[7,8] Therefore, considering that caries and erosion lesions undergo a similar demineralization process, the efficacy of resin infiltration was evaluated within the scope of the present study.

After application of the resin infiltration technique, the reversal of demineralized lesions could be detected visually; however, it can also be demonstrated using quantitative values. Although DIAGNOdent pen device is routinely used to obtain these quantitative values, alternative techniques are being sought because of the technique's high cost.[15,16] It has been reported in studies that the progression or regression of lesions can be indicated using quantitative values obtained from high-resolution photographs.[17,18] The results of the present study showed that there was statistical significance between pre-erosion, post-erosion, and post-treatment stage measurements taken by the DIAGNOdent pen for primary and permanent teeth. The surface analysis results of using the DIAGNOdent pen showed surface saturation against the use of the resin infiltration system in cases of erosion for both primary and permanent teeth within the scope of this study.

The change in the refractive index of light in the affected area causes loss of surface gloss and surface roughness as well as a result of changes in internal reflection. Therefore, the cause of enamel opacity is that porous enamel reflects more light compared with solid enamel.[19,20] In the scope of this study, colorimetric change in the enamel surface was measured by assessing the CIE L*a*b values from each of the photographs that were taken. According to the results, the CIE L values, which indicate lightness, and the CIE a values, which refer to green-red chromaticity in the enamel surface for pre-erosion, post-erosion, and post-treatment photographs, were statistically significant for primary teeth. There was statistical significance for CIE b values between post-erosion and post-treatment measurements, as well as between pre-erosion and post-erosion measurements. However, there was no statistically significant difference between the pre-erosion and post-treatment measurements of primary teeth concerning CIE b values, which refer to blue-yellow chromaticity. Although, CIE b values were not statistically significant, the ΔLab values were statistically significant for erosion development and the resin infiltration technique's efficacy for primary teeth. Therefore, the masking ability of resin infiltration for effecting colorimetric change in cases of erosion lesions in primary teeth should be developed for better chromaticity to increase aesthetic satisfaction.

Furthermore, the results for pre-erosion, post-erosion, and post-treatment photographs of permanent teeth were statistically significant for L*a*b and ΔLab values. These results indicate better masking results for the resin infiltration technique for permanent teeth concerning erosive surface loss. Additional studies[21-24] have noted the masking ability of resin infiltration for permanent teeth as being similar to the results of the present study. Statistically significant results for ΔLab values were compatible with DIAGNOdent pen results for permanent teeth. Andrade *et al*.[25] reported a clinical study including the effect of resin infiltration in cases of white spot lesions and, according to the CIE L*b results statistically significant difference was observed following resin infiltration; however, CIE a values were not statistically significant. According to the results of present study, CIE a values which meant to be the cause of the color change closer to yellow were not statistically significant that is similar with the results of previous study reported by Andrade *et al*.[25]. However, CIE b values which meant to be the cause of color change closer to redness were not statistically significant in the present study. The null hypothesis was rejected due to the presence of statistically significant change in color between pre-erosion, post-erosion, and post-treatment samples. Therefore, initial demineralized lesions with an opaque white appearance caused by erosion could be masked using the resin infiltration technique and should be evaluated in clinical studies to provide additional results before clinical use.

CONCLUSION

The results of the present study showed the masking ability of the resin infiltration technique in cases of erosion by measuring demineralization depth with DIAGNOdent pen and determining CIE L*a*b values derived from the enamel surface analysis. According to these results, resin infiltration could be a solution for the esthetic masking of erosive tooth loss on permanent and primary teeth enamel surfaces. Within the limitations of this study, further studies using larger sample sizes are necessary to clarify the significant difference between pre-erosion, post-erosion, and post-treatment samples as well as clinical studies to determine the effect of oral environment in cases where the resin infiltration technique is considered for erosion lesion treatment.

Funding: This study was approved by the Baskent University Institutional Review Board and Ethics Committee (project no: D-KA 22/17) and supported by Baskent University Research Fund.

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