Araştırma Makalesi *Research Article*

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How Do Endodontic Irrigation Solutions Affect the Surface Roughness of Bulk Fill Resin Composite?

Endodontik İrrigasyon Solüsyonları Bulk Fill Reçine Kompozitin Yüzey Pürüzlülüğünü Nasıl Etkiler?

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ABSTRACT

Objective: The goal is to find out how irrigation and chelating solutions change the average surface roughness (Ra) of resin composites when root canal treatment is done on teeth with composite restorations.
Methods: A total of 40 disc-shaped composite specimens (Tetric®-N-Ceram-Bulk-Fill-IVA) were used in the study. The specimens were randomly divided into 4 groups (n=10) and Ra values were measured before treatment. Group1 (Gr1) was then immersed in 5% sodium hypochlorite (NaOCl), group2 (Gr2) in 17% ethylenediaminetetraacetic acid (EDTA), group3 (Gr3): 10% citric acid (CA), group4 (Gr4): 0.9% saline (SS) for 15 minutes. After treatment, the Ra values of the samples were measured again. Comparison of Ra values before and after treatment was performed by paired samples t-test, and one-way ANOVA analysis was used for comparison between groups.
Results: There was a statistically-significant difference between the 4 groups in terms of post-treatment Ra measurements ($p<0.05$). While there was no statistically-significant difference between the pre-treatment and post-treatment Ra values in NaOCl and SS ($p>0.05$). There is a statistically-significant difference between the pre-treatment and post-treatment Ra values in EDTA and CA ($p<0.05$). There is also a statistically-significant difference between NaOCl and SS and EDTA and CA in terms of post-treatment Ra values ($p<0.05$).
Conclusion: Among the solutions used in our study, EDTA and CA increased the Ra values on resin composites. It is recommended to polish the surface of composite restorations after the treatment to avoid problems related to the increase in roughness after the irrigation procedure.

Keywords: Endodontic irrigation, composite resin, bulk fill, surface roughness

ÖZ

Amaç: Kompozit restorasyonlu dişlere kök kanal tedavisi yapıldığında irrigasyon ve şelasyon solüsyonlarının rezin kompozitlerin ortalama yüzey pürüzlülüğünü (Ra) nasıl değiştirdiğini bulmaktır.
Yöntemler: Çalışmada toplam 40 adet disk şeklinde kompozit numune (Tetric®-N-Ceram-Bulk-Fill-IVA) kullanıldı. Örnekler rastgele 4 gruba (n=10) ayrıldı ve tedavi öncesinde Ra değerleri ölçüldü. Daha sonra; grup 1 (Gr1): %5 sodyum hipoklorit (NaOCl), grup 2 (Gr2): %17 etilendiamintetraasetik asit (EDTA), grup 3 (Gr3): %10 sitrik asit (SA) ve grup 4 (Gr4): %0,9 salin solüsyonu (SS) içine 15 dakika boyunca daldırıldı. Tedavi sonrasında örneklerin Ra değerleri tekrar ölçüldü. Tedavi öncesi ve sonrası Ra değerlerinin karşılaştırılması için bağımlı örneklem t-testi kullanılırken, gruplar arası karşılaştırma için tek yönlü ANOVA analizi kullanıldı.
Bulgular: Tedavi sonrası Ra ölçümleri açısından 4 grup arasında istatistiksel olarak anlamlı fark vardı ($p<0,05$). NaOCl ve SS'de tedavi öncesi ve tedavi sonrası Ra değerleri arasında istatistiksel olarak anlamlı bir fark bulunmazken ($p>0,05$). EDTA ve SA'da tedavi öncesi ve tedavi sonrası Ra değerleri arasında istatistiksel olarak anlamlı fark vardır ($p<0,05$). Ayrıca NaOCl ve SS ile EDTA ve SA arasında tedavi sonrası Ra değerleri açısından da istatistiksel olarak anlamlı farklılık bulunmuştur ($p<0,05$).
Sonuç: Çalışmamızda kullanılan solüsyonlardan EDTA ve SA, rezin kompozitlerde Ra değerlerini arttırmıştır. İrrigasyon işlemi sonrasında pürüzlülük artışına bağlı problemlerin yaşanmaması için kompozit restorasyonların yüzeyinin tedavi sonrasında cilalanması tavsiye edilir.

Anahtar Kelimeler : Endodontik irrigasyon, kompozit rezin, bulk fill, yüzey pürüzlülüğü

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INTRODUCTION

Composite resins are being increasingly used throughout the world due to their ever-improving mechanical and physical properties, the availability of effective adhesive systems, improved clinical properties, acceptable esthetic properties with tooth-like color and translucency, and increasing public concern about the use of amalgam. The increasing demand for these restorative materials has led to the emergence of a wide range of products over time.[1,2] Bulk fill composites, which have recently become more widely used, are available in the dental markets in two main forms: flowable and higher viscosity, with various variations. The advantages of bulk fillings include reduced polymerization shrinkage, increased polymerization depth and reduced chair time, which are of great importance to both clinicians and patients.[3,4]

One of the most important features to be considered in composite resin restorations is the roughness left on the surface of the restoration after various finishing polishing procedures. There are various composite resins available on the dental market from different companies. These different materials contain different proportions of filler and matrix. These differences also affect the roughness on the surface of the restoration after final polishing. The ratio of roughness to lustre in the restorative material is directly related to the aesthetic expectations of the patient and the biological success of the restoration.[5] Finishing is the grinding and shaping of restoration surfaces to mimic the lost tooth tissue anatomy. Polishing, on the other hand, is the removal of scratches and roughness created on the restoration surface during the finishing process and the attempt to achieve an enamel-like lustrous surface.[6-8] This is very important because, in addition to meeting aesthetic expectations, a shiny restoration surface prevents staining of the restoration, plaque and biofilm accumulation on the tooth surface, recurrent caries, secondary infection in root canal-treated teeth, gingival irritation, increased abrasion of the filling surface and the patient's sensation of constantly touching the rough surface with the tongue.[7,8]

A change of 0.25-0.5 µm on the surface of the restoration is perceived by the patient's tongue and negatively affects patient comfort.[9] Wear resistance depends on the polymerization quality of the resin composite used, the filler to matrix ratio, the shape and size of the filler and the polymerization thickness of the material. The gloss and wear resistance of properly finished and polished restoration surfaces can deteriorate over time due to factors such as pH, temperature, dietary and brushing habits, and poor oral hygiene.[10,11] When root canal treatment is performed on teeth with composite restorations, the tooth and restoration surfaces remain in contact with various endodontic solutions for a period of time. Due to the different pH values and chemical properties of these solutions, abrasions may occur on the restoration surface, microhardness may decrease, gloss may deteriorate, and Ra values may increase.[12,13]

Although the importance of composite resin restorations in endodontics is well known in many aspects such as coronal sealing and prevention of secondary caries, there are not many studies in the literature on the roughening effects of these solutions on composite resin restorations. In our study, different solutions are used in routine endodontic practice and their roughening effects on resin materials are investigated. Our null hypothesis is that there is no difference between the endodontic solutions in terms of their roughening effect on composite restorative resins.

METHODS

Sample size determination

According to the results of the power analysis performed with the G-Power program (G*Power 3.1 Software; Heinrich-Heine-University, Düsseldorf, Germany) as part of the study; for the F-test, Anova: Fixed Effect Omnibus, one-way analysis, it was determined that 10 samples were required in each subgroup, with a minimum of 40 in total, at the level of 0.55 effect (f) and 0.80 power (1-β) when α (margin of error) of the study was 0.05.

Informed Consent and Ethics Committee Approval

Our study investigated the roughening effect of solutions on composite resins. Since the study did not involve any medical materials, images, or questionnaires containing patient information from humans or animals, no informed consent or ethics committee approval is required.

Sample preparation

The composite resin used in our study was Tetric® N-Ceram Bulk Fill IVA (TCNB) (Ivoclar, Vivadent AG, Schaan, Liechtenstein) (Table 1). A total of 40 disc-shaped composite resin specimens were prepared using a round silicone mould with a diameter of 7 mm and a height of 3 mm. The silicone mould was placed on a strip of clear Mylar matrix (Palmero Healthcare, 120 Goodwin Place, CT, 06615, USA) supported by a 2 mm thick glass plate. After composite loading of the mould, a second transparent Mylar strip was placed on top. A second 2mm glass sheet was placed on top of this strip. In order to remove the overflowing material from the silicone mould and to obtain a more homogeneous, non-porous and smooth surface, the glass sheet was pressed with a force of 500 g for 30 s. The glass sheet was then removed, and the composite resin samples were light polymerized over the Mylar matrix strip to avoid the formation of an oxygen inhibited layer.

Table 1. Properties of Bulk-fill resin composite material used in the study.

Resin Composite	Type	Composition	Filler Wt/Vol	Manufacturer	Lot Number
Tetric® N-Ceram Bulk Fill IVB	Nanohybrid Bulk Fill	Matrix: Bis-GMA, Bis-EMA, UDMA, Polymer filler (%17) (Ba-Al-Si glass filler, Ytterbium trifluoride), mixed oxides, additives, catalyst, stabilizers, and pigments	75-77 % by weight 53-55 % by volume Filler size: 0,04-3 µm	Ivoclar Vivadent AG, Schaan, Liechtenstein	W42311

Bis-GMA: Bisphenol A glycidyl methacrylate
Bis-EMA: Ethoxylated bisphenol A glycol dimethacrylate
UDMA: Urethane dimethacrylate

Each composite resin specimen was polymerized using an LED light polymerization device (X-Cure, Woodpecker, Medical Instrument, Guangxi, China) with active light calibrated at 1200 mw/cm2 for 20 s (separately on the upper and lower surfaces of the specimen) according to the manufacturer's instructions. The probe tip of the LED light device was placed on the specimen at a distance of approximately 1 mm and at right angles to the specimen. The underside of each specimen was marked with an indelible pencil to prevent interference between the top and bottom surfaces. The demoulded samples were stored in a container in an incubator at 37°C and distilled water for 24 hours. The specimens were then ground with water-cooled #500, #600, #800, #1000 and #1200 grit sandpaper and polished with DirectDia diamond polishing paste (Shofu Dental Corp., PN 0558, DirectDia, Shofu Inc., Kyoto, Japan). The samples were then randomly divided into 4 groups (n=10).

Quantitative evaluation of Ra was performed using a digital surface profilometer (Surftest sj-410, Mitutoyo Corp., Kanagawa, Japan) at a tip feed rate of 0.5 mm/s, a cut point of 0.8 mm and a trace length of 5 mm. Three measurements were taken from the top surface of each sample and from different parts of the surface, and the average Ra values of the sample before processing were calculated by taking the arithmetic averages. The averages were tabulated and recorded as "pre-treatment average Ra values" in µm. The samples were then immersed in different endodontic solutions Gr1: 5% NaOCl, Gr2: 17% EDTA, Gr3: 10% CA, Group 4 (Gr4): 0.9% SS for 15 minutes.

The samples were then rinsed with an air-water spray for 10 seconds. Quantitative Ra measurements were performed using a profilometer device to measure Ra values after treatment. For all samples, 3 measurements were taken from the top surface and different parts of the surface, the arithmetic mean was taken, tabulated, and recorded as 'average Ra values after treatment' in µm. The pre- and post-treatment Ra values were then statistically analyzed.

Statistical analysis

As part of the study, statistical analyses were performed using the SPSS 26.0 software package. Firstly, the normality of the distribution was checked using the Kolmogorov-Smirnov and Shapiro-Wilk tests. According to the results obtained, it was concluded that the data had a normal distribution and parametric tests were considered appropriate. The paired samples t-test was used to compare the pre-treatment and post-treatment measurements of Ra values, while one-way ANOVA analysis was used to compare the groups. The Bonferroni test was used as a post hoc test for significant results. Statistical significance was accepted as p<0.05 throughout the study.

Table 2. Normality Test (df: degree of freedom, p: p-value=probability)

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	p	Statistic	df	p
Pre-treatment	0,098	40	,200*	0,949	40	0,069
Post-treatment	0,108	40	,200*	0,946	40	0,056

RESULTS

The study included 10 samples in each solution group. According to the results obtained, there was no statistically significant difference between the 4 groups in terms of pre-treatment Ra measurements (p>0.05). The pre-treatment Ra values of the groups were found to be close to each other (Table 3).

Table 3. Pre-Treatment Ra Measurements (Gr: Group, NaOCl: Sodium hypochlorite, EDTA: Ethylenediaminetetraacetic acid, N: number, S.D.: Standard Deviation, p: p-value=probability)

	N	Minimum	Maximum	Average ± S.D.	p
Gr1(NaOCl)	10	0,144	0,292	0,198±0,048	0,933
Gr2(EDTA)	10	0,141	0,264	0,196±0,037	
Gr3(Citric Acid)	10	0,151	0,262	0,200±0,037	
Gr4(Saline)	10	0,140	0,260	0,189±0,043	

There is a statistically significant difference between the 4 groups in terms of post-treatment Ra measurements (p<0.05). When the comparisons between the groups were analyzed in detail using the post-hoc test, the lowest post-treatment Ra value was found in the SS group and the highest Ra value was found in the CA group. While the post-treatment Ra values of the NaOCl and SS groups were close to each other and there was no significant difference between them, there was a significant difference between these two groups and the EDTA and CA groups. Similarly, there was no significant difference between the EDTA and CA groups (Table 4).

Table 4. Post-Treatment Ra Measurements (Gr: Group, NaOCl: Sodium hypochlorite, EDTA: Ethylenediaminetetraacetic acid, N: number, S.D.: Standard Deviation, p: p-value=probability *Exponential letters are used to indicate the difference between groups. There was no significant difference between groups receiving the same letter.)

	N	Minimum	Maximum	Average ± S.D.	p
Gr1(NaOCl)	10	0,141	0,297	0,205±0,053 [a]	0,001
Gr2(EDTA)	10	0,244	0,381	0,298±0,044 [b]	
Gr3(Citric Acid)	10	0,258	0,371	0,314±0,034 [b]	
Gr4(Saline)	10	0,148	0,281	0,190±0,044 [a]	

There is no statistically significant difference between the pre-treatment and post-treatment Ra values of the NaOCl solution samples (p>0.05). There was no significant change in Ra values after treatment. There is a statistically significant difference between the pre-treatment and post-treatment Ra values of EDTA solution samples (p<0.05). After treatment, the average Ra value increased and showed a significant difference. There is a statistically significant difference between the pre-treatment and post-treatment Ra values of CA solution samples (p<0.05). After treatment, the average Ra value increased and showed a significant difference. There is no statistically significant difference between the pre-treatment and post-treatment Ra values of SS samples (p>0.05). There was no significant change in Ra values after treatment.

When analyzing the difference values between pre-treatment and post-treatment, the highest value was observed in CA with 0.114 and the lowest value was observed in SS with 0.001. There was no statistically significant difference between NaOCl and SS and no statistically significant difference between EDTA and CA. EDTA and CA have a statistically significant difference with NaOCl and SS (Table 5). According to the difference values, which can also be expressed as roughening power, the strongest roughening effect was observed with CA, while the least roughening effect was observed with SS).

Table 5. Comparison of the Difference Measurements of the Pre- and Post-treatment values (Gr: Group, NaOCl: Sodium hypochlorite, EDTA: Ethylenediaminetetraacetic acid, N: number, Dif: Difference, p: p-value= probability)

	N	Minimum	Maximum	Average ± S.D.	p
Gr1(NaOCl)	10	**0,198**±0,048	**0,205**±0,053	**0,007**±0,064[a]	0,747
Gr2(EDTA)	10	**0,196**±0,037	**0,298**±0,044	**0,102**±0,060[b]	**0,001**
Gr3(Citric Acid)	10	**0,200**±0,037	**0,314**±0,034	**0,114**±0,058[b]	**0,001**
Gr4(Saline)	10	**0,189**±0,043	**0,190**±0,044	**0,001**±0,077[a]	0,958

DISCUSSION

Composite resin materials can change over time due to dietary habits, oral hygiene habits (brushing, flossing or use of mouthwash solutions, etc.) and various mechanical and chemical mechanisms. The composition and physical and chemical properties of the material are important in these changes.[14-16] In general, the physicochemical properties of the filler particles, including their size, concentration, shape, and the structure of the filler matrix, are among the most important factors that play a role in the wear resistance of the material.[17] The increasing aesthetic expectations and demands of patients have further encouraged dentists and dental material manufacturers to develop composite resin materials and new application methods. In aesthetic restorative dentistry, the aim is to achieve a lustrous and smooth restoration surface that mimics the enamel surface of the natural tooth, which is invisible to the eye and not felt by the patient's tongue.[18] Various finishing polishing systems have been proposed in the literature to increase the abrasion resistance of the restoration, ensure color stability, and achieve the desired smoothness.[19,20] In our study, bulk-fill composites, whose use and popularity among dentists is increasing day by day due to their advantages that we can put a larger amount of resin at once and provide faster processing ease, were preferred instead of the incremental method, which is small and time-consuming. In the study, sandpaper (500, 600, 800, 1000, 1200 grit) was used to finish the composite specimens and DirectDia diamond-impregnated polishing paste containing 20% diamond powder was used for polishing. The advantages of the paste are that it cleans both phases of the resin composite material homogeneously, can be used on wet tooth surfaces, remains on the tooth surface during the procedure and can be cleaned quickly when rinsed.

As different irrigation solutions have different pH levels and chemical structures, they have different roughening effects on different materials. The effects of irrigation solutions and chelating agents on many tissues and materials such as root canal dentin, endodontic nickel-titanium files and bio-ceramic cements have been studied.[21,22] Many dental procedures and mouthwashes that cause Ra on composite resins have been investigated in various studies.[5,6,9-11] However, there is no study in the literature that investigates the Ra changes caused by endodontic irrigation solutions on composite resins.

Irrigation solutions have various effects on dentin, such as removing the smear layer, exposing dentin tubules, reducing dentin micro- and nano-hardness and creating dentin surface roughness.[23-25] Dentin surface roughness is a factor that plays an important role in the micromechanical bond of sealants. Ari et al. showed that 2.5% to 5.25% NaOCl caused a significant increase in dentin roughness.[21]

It has also been reported that EDTA has a detrimental effect on dentin Ra.[25]. Ari et al[21]'in 2004 reported a significant increase in Ra on root canal dentin when rinsed with 17% EDTA. Other dentin properties such as micro- and nano-hardness have also been reported to be altered by chelating agents.[23]

A study has shown that irrigation solutions cause changes not only in dentin but also in Portland cement (PC), a bioceramic.[24,26,27] The results of this study showed that NaOCl at a concentration of 5% significantly decreased the Ra of PC, whereas 20% CA significantly increased the Ra. In addition, the Ra and cyclic fatigue changes of irrigation solutions on files, which are the main mechanical expansion instruments in root canal treatment, have also been investigated in various studies.[28-31] One study examined the Ra values of 5.25% NaOCl before and after application to Protaper Next (PTN), Hyflex CM (CM), Hyflex EDM (EDM), WaveOne gold (WOG) and Trunatomy (TN) files. As a result, all rotary endodontic instruments tested showed an increase in Ra to varying degrees, with the least increase in Ra observed with TN and PTN instruments.[32]

High quality finishing and polishing of dental restorations is very important in prolonging the life of teeth and maintaining their aesthetics for many years.[33,34] The Ra of composite resins depends on some extrinsic factors, which are experience, skill and ability of the operator to apply the technique, are mainly related to the finishing and polishing processes and include any physical properties of the polishing tools. This is important for our study because some of the irrigation solutions (EDTA and CA) were found to increase the Ra of the composites in our study results. This affects the sealing and longevity of composite fillings and thus the long-term postoperative success of endodontic treatment.

Irrigation solutions used to remove the smear layer from the root surface. NaOCl is used to remove the organic component and EDTA is used to remove the inorganic component of the smear layer. As the smear layer is removed, the surface roughness will increase.[33,35] In our study, we investigated in vitro how resin restorations are affected by irrigation solutions in terms of Ra changes during endodontic treatment of teeth with composite restorations. While no statistically significant difference was observed in the Ra of the resin composite specimens after treatment with NaOCl and SS, the surface Ra values of the specimens immersed in EDTA and CA increased statistically significantly compared to the pre-treatment. Therefore, the null hypothesis of our study was rejected.

Microhardness, color, or Ra changes can occur on dentin and many materials after rinsing with various solutions.[20-22,33] There are many disadvantages of composite resins or roughness on the tooth surface, such as deterioration of the aesthetic appearance, staining of the tooth or restoration, more plaque and biofilm accumulation on the tooth surface than on the shiny surface, recurrent caries, secondary infection of root canal treated teeth, gingival irritation, septal pain, increased abrasion on the filling surface and discomfort caused by increased tactile sensation with the patient's tongue.[7,8] Limitations of the study included the in vitro nature of the study, which did not fully simulate clinical conditions. In addition, in future in vitro and in vivo studies, the use of different types and properties of composites and the examination of microhardness and color changes on composites will help us to better understand the effects of irrigation and chelating agents on resin composite restorations.

CONCLUSION

Our study showed that irrigation with chelating agents (EDTA and CA) resulted in an increase in Ra values on composite resin surfaces. It is recommended that an additional polishing step be performed on the resin composite restoration surface after completion of the root canal treatment to avoid the negative effects that may be caused by the formation of roughness after endodontic irrigation.

Etik Komite Onayı: Çalışmamızda solüsyonların kompozit rezinler üzerindeki pürüzlendirme etkisi araştırıldı. Çalışma, insanlardan veya hayvanlardan alınan hasta bilgilerini içeren herhangi bir tıbbi malzeme, görüntü veya anket içermediğinden etik kurul onayı gerekmemektedir.
Hasta Onamı: Çalışma, hastanın diseke edilmesine veya hayvanlardan parça alınmasına ilişkin herhangi bir tıbbi malzeme, görüntü veya anket içermediğinden bilgilendirilmiş onam alınmadı.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir – C.T., F.Ö.; Tasarım – C.T.; Denetleme – F.Ö.; Kaynaklar – C.T.; Veri Toplanması ve/veya İşlemesi – C.T.; Analiz ve/veya Yorum – F.Ö.; Literatür Taraması – C.T.; Makaleyi Yazan – C.T.; Eleştirel İnceleme – F.Ö.
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Ethics Committee Approval: In our study, the etching effect of solutions on composite resins was investigated. Ethics committee approval is not required as the study does not contain any medical materials, images or surveys containing patient information from humans or animals.
Informed Consent: Informed consent was not obtained because the study did not involve any medical materials, images, or surveys involving the patient being dissected or taken from animals.
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