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Research Araştırma

Effect of Remaining Dentin Thickness on Thermal Changes at The Root Surface During Obturation With Thermoplasticized Gutta-Percha In Internal Resorption Cavities

İnternal Rezorpsiyon Kavitelerinde Termoplastik Gutta-Perka ile Doldurulması Sırasında Kök Yüzeyinde Oluşan Termal Değişiklikler Üzerinde Kalan Dentin Kalınlığının Etkisi

ABSTRACT

Objective: The treatment of internal resorption focuses on removing necrotic pulp tissue, disinfecting the root canal and fill the root canal ystem, including the resorption zone. Warm gutta-percha techniques are commonly recommended for sealing resorption defects due to their flowable properties, however, concerns persist regarding temperature increases during the obturation process. This study aims to investigate the impact of remaining dentin thickness on temperature changes at the root surface during thermoplasticized gutta-percha obturation in simulated internal resorption cavities.

Materials and Method: Thirty maxillary central incisor teeth were used. The teeth were divided into two halves. A resorption cavity was created on one root half, while the other half was served as the control. The teeth were divided into three groups based on the remaining dentin thickness in the halves that containing the internal resorption cavity (0.4 mm, 0.7 mm, and 1 mm). Temperature changes during the thermoplastic gutta-percha obturation were measured using thermocouples. A paired samples t-test was conducted to assess the differences between the resorptive and control surfaces, and a one-way ANOVA test was applied to evaluate the temperature variations across the groups.

Results: Statistically significant temperature differences were observed between the resorption and control surfaces in all groups, no significant differences were found among the three dentin thickness groups.

Conclusion: The study concludes that internal resorption cavities result in higher temperature transmission at the root surface during thermoplasticized gutta-percha obturation, irrespective regardless of dentin thickness. However, no significant differences in temperature were observed across different dentin thicknesses.

Key Words: Dentin, Gutta-Percha, Root Resorption, Thermoplastic Techniques.

ÖZ

Amaç: İnternal rezorpsiyon tedavisi nekrotik pulpa dokusunun uzaklaştırılmasına, kök kanalını dezenfekte edilmesine ve rezorpsiyon bölgesi de dahil olmak üzere kök kanal sisteminin doldurulmasına odaklanır. Sıcak güta-perka teknikleri, akışkan özelliklerinden dolayı genellikle rezorpsiyon defektlerini kapatmak için önerilmektedir. Ancak, obturasyon işlemi sırasında oluşabilecek sıcaklık artışları ilgili endişeler devam etmektedir. Bu çalışma, simule edilmiş iç rezorpsiyon boşluklarının termoplastize güta-perka ile obturasyonu sırasında kalan dentin kalınlığının kök yüzeyindeki sıcaklık değişimleri üzerindeki etkisi araştırılmıştır.

Gereç ve Yöntemler: Otuz adet maksiller santral kesici dişi kullanılmıştır. Dişler iki yarıma ayrılmıştır. Bir kök yarısında bir rezorpsiyon kavitesi oluşturulurken, diğer yarısı kontrol grubu olarak kullanıldı. Dişler, iç rezorpsiyon boşluğunu içeren yarılardaki kalan dentin kalınlığına göre üç gruba ayrıldı (0.4 mm, 0.7 mm ve 1 mm). Termoplastik gutta-perka ile doldurulması sırasında meydana gelen sıcaklık değişiklikleri thermocouple kullanılarak ölçüldü. Rezorpsiyonlu ve kontrol yüzeyleri arasındaki farkları değerlendirmek için eşleştirilmiş örneklem t-testi, gruplar arasındaki sıcaklık değişimlerini değerlendirmek için ise tek yönlü ANOVA testi kullanıldı.

Bulgular: Tüm gruplarda rezorpsiyon ve kontrol yüzeyleri arasında istatistiksel olarak anlamlı sıcaklık farkları gözlendi, ancak üç dentin kalınlığı grubu arasında anlamlı bir fark bulunmamıştır.

Sonuç: Çalışma, iç rezorpsiyon boşluklarının, dentin kalınlığından bağımsız olarak, termoplastik gutta-perka obtürasyonu sırasında kök yüzeyinde daha yüksek sıcaklık iletimine yol açtığı sonucuna varılmıştır, Ancak farklı dentin kalınlıkları arasında sıcaklık açısından anlamlı bir fark gözlenmemiştir.

Anahtar Kelimeler: Dentin, Gutta-Perka, Kök Rezorpsiyonu, Termoplastik Teknikler.

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INTRODUCTION

Resorption of dental tissues can occur due to clastic activity, arising from either physiological or pathological processes (1). Internal root resorption (IRR), a form of pathological root resorption, typically results from trauma or prolonged pulp infections. If left untreated, IRR is characterized by a progressive destruction of root dentin through an inflammatory process (1, 2). This condition leads to the formation of a granulation tissue-filled cavity, complicating proper root canal preparation and obturation. The primary objectives in treating teeth affected by IRR is to remove necrotic pulp tissue, disinfect the root canal system and achieve a three-dimensional filling of the root canal, including the resorption zone. This is accomplished through chemo-mechanical preparation, aiming to halt the resorption process (1). Cases of IRR present significant challenges in achieving complete root canal obturation (1). To effectively seal resorptive defects, the filling material must possess adequate flowable properties. Gutta-percha remains the most commonly used obturation material, and its flowability can be enhanced through heating (3, 4). Several obturation systems utilizing warm gutta-percha have been developed, with studies demonstrating their effectiveness in filling the irregularities associated with IRR (5-7). However, despite the low thermal conductivity of dental tissues (8), temperature increases on the root surface remain a significant concern with warm gutta-percha techniques (9-12). Previous research shows that a temperature rise of 10 ˚C can result in fat cell necrosis and bone remodeling in rabbits (13). This article aimed to investigate the impact of remaining dentin thickness in artificially created internal resorption cavities on temperature changes at the root surface. The null hypothesis was that the remaining dentin thickness in internal root resorption cavities directly affect temperature increases at the root surface.

MATERIAL AND METHODS

The protocol of this study was approved by Ordu University clinical research ethics committee (ODU KAEK 2016/70). The total sample size required for the study was determined based on the data from a previous study (14) using the G*Power 3.1 software package (Heinrich). Based on the F-test family, an effect size of 0.660, an alpha type error of 0.05, and a power of 0.85, the minimum total sample size required was calculated as 30. Human maxillary incisors extracted due to orthodontic, periodontal, or prosthetic reasons were included in the study. Teeth with caries or fractures in the roots were excluded from the study. Thirty teeth with a single root canal were randomly allocated into three groups. Teeth were decoronated using a diamond disc under water-cooling to standardize 17 mm root length. A #15 K-file was inserted into each root canal until the tip was visible at the apical foramen, and 1 mm was subtracted from this measurement to establish the working length. The root canals were prepared using the Reciproc Blue system (VDW, Munich, Germany) up to the R50 file (50.05) with copious irrigation using 5.25% NaOCl via a 30-gauge irrigation needle (NaviTip; Ultradent, South Jordan, UT). Longitudinal grooves were created on the palatal and buccal surfaces of the roots, and the roots were split into halves using a hammer and chisel. A digital micrometer was employed to determine the location of the resorption cavity and the initial dentin thickness of the root halves. A test apparatus was custom-designed for this study to create resorption cavity under controlled conditions. This apparatus consisted of a diamond bur mounted on a motor capable of moving vertically in electronically controlled increments of 0.1, 1, and 10 mm (Figure 1A). Simulated resorption cavities with a diameter of 1.6 mm were prepared on one root half at a distance of 5 mm from the root tip, resulting in remaining dentin thicknesses of 0.4 mm, 0.7 mm, and 1 mm (Figure 1B). The remaining dentin thickness was confirmed using a digital micrometer. The other half of the root was served as the control. A red dot was marked on the surfaces of both root halves using a CD marker to indicate the sites for subsequent temperature measurements with a thermocouple. The two halves were then reassembled using cyanoacrylate glue (Scotch Super Glue Gel; 3M, St Paul, MN).

The experimental groups were categorized as below:

Group 1: Simulated resorption cavities with a remaining dentin thickness of 0.4 mm (n=10) and their corresponding control halves is the plural of half.
Group 2: Simulated resorption cavities with a remaining dentin thickness of 0.7 mm (*n=10*) and their corresponding control halves is the plural of half.
Group 3: Simulated resorption cavity with a remaining dentin thickness of 1 mm (n=10) and their corresponding control halves is the plural of half.

A plastic apparatus was designed to securely hold the sample and thermocouple tips during the root canal obturation of the roots (Figure 1C). K-type thermocouple tips were affixed to the red markings on the root surfaces using heat insulation paste. The downpack handpiece of the ElementsFree obturation system (SybronEndo/Kerr Endodontics, Orange, CA). was used to deliver thermoplasticized injectable gutta-percha material at 200 ˚C into the root canals. All teeth across the groups were obturated under standardized room conditions on the same day. The maximum temperature on the surface of the resorption cavity and the corresponding area on the control half was recorded using the thermocouple.

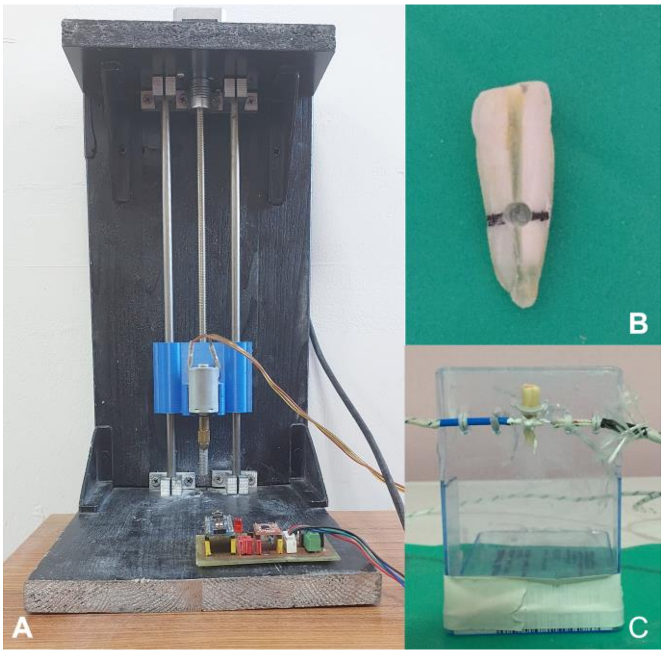

Figure 1. A, the test apparatus designed to prepare the internal resorption cavity with precise remaining dentin thickness; **B**, the resorption cavity that prepared using the apparatus; **C**, the test setup where measurement is made by using thermocouple.

Statistical Analysis

The Shapiro-Wilk test confirmed that the data were followed a normal distribution. For each dentin thickness, a paired samples t-test was conducted to compare the temperature differences between the surface with the resorptive cavity and the control surface. To determine whether significant differences existed in the temperatures transmitted outside the root among the three different dentin thicknesses, a one-way ANOVA was performed with a 95% confidence level. All analyses were conducted using SPSS software (SPSS Inc, Chicago, IL).

RESULTS

The maximum temperature values recorded in this in vitro study were 35.6 ˚C for a remaining dentin thickness of 0.4 mm on resorption cavities, 34.4 ˚C for 0.7 mm, and 34.2 ˚C for 1 mm. The temperature differences between the resorptive surface and the control surface were statistically significant across all three thickness groups (Groups 1, 2, and 3) (p = 0.002, 0.014, and 0.023, respectively). In all groups, the mean maximum temperatures recorded on the control surface were lower than those on the resorptive surface. The mean maximum temperature values recorded at the root surface for the different dentin thickness groups are presented in Table 1. No statistically significant difference was observed among the groups regarding the mean maximum temperature values reached on the root surface

Table 1. The mean and standard deviation of the maximum temperature values recorded on root surfaces with varying remaining dentin thicknesses.

Dentin Thickness	Mean Max. Temperature	Std. Deviation	n	p
Group 1 (0.4 mm)	32.35	2.29	10	0.437
Group 2 (0.7 mm)	31.02	3.02	10	
Group 3 (1 mm)	30.90	2.80	10	

DISCUSSION

Studies have demonstrated that internal resorption cases and root canal irregularities are sealed more effectively using warm thermoplastic filling techniques compared to the cold lateral condensation (5-7). However, the use of heat in thermoplasticized root canal obturation techniques to enhance the flowability of gutta-percha can result in an increase in temperature at the root surface (9-12, 14-17). A temperature rise exceeding 10 degrees at the root surface is a concern in root canal treatment, as it may lead to pathological changes in the periodontal tissues (13). This study examined the temperature variations transmitted outside the root in internal resorption cavities with three different dentin thicknesses. In all groups with varying dentin thicknesses, the temperature transmitted outside the root was found to be higher than that in the control group, which lacked an internal resorption cavity. These findings suggest that the presence of an internal resorption cavity increases the temperature transmitted outside the root during thermoplastic filling techniques. Although the mean maximum temperature transmitted outside the root appeared to increase as the dentin thickness decreased, no statistically significant differences were observed among the different dentin thicknesses. Lipski (2006) evaluated the temperature rise on the root surface during root canal filling with injectable warm gutta-percha, reporting that mandibular central incisors exhibited a temperature increase three times higher than that of maxillary central incisors (11). Two additional studies on this subject observed that while the temperature rises in maxillary incisor teeth remained below the critical threshold, those in mandibular central incisor teeth exceeded the critical threshold of 10 ˚C (15, 17). This difference was attributed to the thinner dentin in mandibular central incisors compared to maxillary central incisors and canines. In our study, although an increase in the temperatures transmitted to the root surface was observed as dentin thickness decreased, no statistically significant differences were found between the groups. These findings align with studies demonstrating that thinner dentin facilitates greater temperature transmission during thermoplastic filling procedures. Ulusoy et al. (2015) compared the temperature values transmitted outside the root in teeth with internal resorption using three different root canal filling methods. They reported higher temperature values in resorbed teeth within the group where the thermoplasticized injectable gutta-percha method (Obtura II) was used, compared to those without a resorption cavity (9). Their findings align with the result of this study. Additionally, they reported that the temperature transmitted outside the root using this method exceeded the critical threshold of 10 ˚C. Similarly, in our study, the maximum temperature values reached approximately 36 ˚C during experiments conducted at a room temperature of around 22 ˚C, surpassing the critical threshold. One limitation of this study is that the experiments were conducted at room temperature, which may have influenced or moderated the recorded temperatures. Additionally, a finite element analysis study (18) demonstrated that in models without blood flow, the temperatures transmitted outside the root canal were higher compared to models with blood flow. The lack of simulation for the surrounding periodontal ligament and blood flow in our study suggests that the recorded temperature increases may not fully represent clinical reality. Consequently, these limitations may impact the validity of the temperature data in terms of clinical applications. Future research should consider utilizing models that account for the effects of the periodontal ligament and blood flow, and body temperature.

CONCLUSION

The findings indicated that the presence of an internal resorption cavity significantly increased the temperature transmitted outside the root, regardless of the remaining dentin thickness. Although a trend of higher temperature transmission with decreasing dentin thickness was observed, no statistically significant differences were detected among the groups in terms of maximum temperature values. These results suggest that while thermoplastic filling techniques are effective for achieving adequate obturation in cases of IRR, clinicians should exercise cautious regarding potential temperature increases that may negatively impact periodontal tissues.

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