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Penetration of AH Plus Bioceramic Sealer into Lateral Canals Using Different Filling Techniques

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Research Article

History

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ABSTRACT

Objectives: Lateral canals within the root canal system may contribute to the development of apical periodontitis, which can negatively affect the success of endodontic treatment. The aim of the study was to assess the depth of penetration of AH Plus Bioceramic root canal obturating sealer into lateral canals, using different obturation techniques on 3D-printed teeth.

Materials and Methods: The study used 45 3D-printed lateral incisors with a working length of 22 mm, an apical tip diameter of 0.30 mm and a lateral canal diameter of 0.15 mm at a distance of 3 mm from the apex. All canals were prepared with Endoart Touch Gold files to a size of 35/.06. The canals were irrigated with distilled water during preparation. After preparation, the main and lateral canal openings were checked with a #10 K file. Teeth were randomly divided into three groups according to obturation technique: Single cone method (n = 15), cold lateral condensation (n = 15) and warm vertical condensation (n = 15). The teeth were obturated with AH Plus Bioceramic root canal sealer and gutta-percha. After obturation, the teeth were radiographed and scored. The results were statistically analysed using Kruskal-Wallis and Mann-Whitney U tests and a significance level of $p < 0.05$ was accepted.

Results: Different obturation techniques used in the study influenced the penetration of the root canal filling material into the lateral canals ($p = 0.002$). When the warm vertical compaction technique was used, AH Plus Bioceramic canal sealer penetrated into lateral canals better than the single cone ($p = 0.001$) and cold lateral condensation ($p = 0.010$) techniques.

Conclusions: The obturation technique used affected the obturation depth of the lateral canals of the AH Plus Bioceramic root canal sealer. The warm vertical condensation technique was found to be more successful than other techniques.

Keywords: Endodontics, root canal obturation, bioceramics, 3D printing, lateral canals

Farklı Dolum Teknikleri Kullanılarak AH Plus Biyoseramik Patının Lateral Kanallara Penetrasyonu

Araştırma Makalesi

Süreç

Geliş: 25/06/2025
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ÖZ

Amaç: Kök kanal sistemi içerisindeki lateral kanallar, apikal periodontitis gelişimine zemin hazırlayabilir ve bu durum endodontik tedavinin başarısını olumsuz etkileyebilir. Çalışmanın amacı, 3 boyutlu yazıcı ile üretilmiş dişlerde farklı obturasyon teknikleri kullanarak AH Plus Biyoseramik kök kanal dolgu patının lateral kanallara penetrasyonunu değerlendirmekti.

Gereç ve Yöntemler: Çalışmada, çalışma uzunluğu 22 mm, apikal uç çapı 0,30 mm ve apikalden 3 mm uzaklıkta lateral kanal çapı 0,15 mm olan 45 adet 3 boyutlu yazıcı ile üretilmiş lateral kesici diş kullanıldı. Tüm kanallar Endoart Touch Gold eğeleri ile 35/.06 boyutuna kadar prepare edildi. Preparasyon sırasında kanalların distile su ile irrigasyonu yapıldı. Preparasyon sonrasında, ana ve lateral kanal açıklıkları #10 K eğe ile kontrol edildi. Ardından dişler obturasyon tekniğine göre rastgele üç gruba ayrıldı: Tek kon yöntemi (n = 15), soğuk lateral kondensasyon (n = 15) ve sıcak vertikal kondensasyon (n = 15). Dişler, AH Plus Biyoseramik kök kanal dolgu patı ve gutta-perka ile doldurulduu. Obturasyonun ardından dişler radyografi alınarak skorlandı. Kruskall-Wallis ve Mann-Whitney U testleri ile istatistiksel olarak analiz edildi ve $p < 0,05$ anlamlılık düzeyi kabul edildi.

Bulgular: Çalışmada kullanılan farklı obturasyon teknikleri, kök kanal dolgu materyalinin lateral kanallara nüfuz etmesini etkiledi (p = 0,002). Sıcak dikey sıkıştırma tekniği kullanıldığında, AH Plus Biyoseramik kök kanal patı, tek kon (p = 0,001) ve soğuk lateral kondensasyon (p = 0,010) yöntemlerine göre lateral kanallara daha iyi penetre oldu.

Sonuçlar: Kullanılan obturasyon tekniği, AH Plus Biyoseramik kanal dolgu patının lateral kanallara penetrasyon derinliğini etkiledi. Sıcak dikey sıkıştırma tekniğinin diğer tekniklere göre daha başarılı olduğu görüldü.

Anahtar Kelimeler: Endodonti, kök kanal obturasyonu, biyoseramikler, 3D printing, lateral kanallar

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Introduction

The main aim of root canal treatment is to hermetically fill the root canal cavity with an inert, biocompatible material to prevent bacterial leakage and reinfection of the root canal system.[1,2] Because of the presence of anatomical variations, including accessory and lateral canals, thorough filling of the root canal system cannot always be accomplished.[3] These anatomical variations may harbor necrotic debris or residual microorganisms, serving as persistent sources of infection and leading to treatment failure.[4] Nevertheless, several investigations have reported that obturating lateral canals can enhance treatment success rates.[1,5]

De Deus et al.[6] study found that lateral canals occurred in 27.4% of teeth, predominantly in the apical third. Seltzer et al.[7] demonstrated that the presence of lateral and accessory canals should be considered a normal anatomical characteristic of the root canal system. As a result, the obturation process should address the entire root canal system, including lateral and accessory canals, to enhance treatment outcomes.[8]

The use of 3D printing technology is widely accepted in dentistry and has recently been incorporated into current endodontic procedures. It has been utilized to create various models for both educational and research purposes, such as comparing the different rotary instruments,[9] obturation techniques[10] and various irrigation methods.[11] In contemporary dentistry, advanced three-dimensional models can be fabricated with high precision through 3D printing technologies utilizing photopolymer resins, including Digital Light Processing (DLP), Selective Laser Sintering (SLS), Fused Deposition Modelling (FDM), Selective Laser Melting (SLM), and Stereolithography (SLA).[12]

Root canals are filled with gutta-percha and root canal filling sealer. Various root canal filling techniques such as cold lateral condensation, single cone, and warm vertical compaction can be used during root canal filling.[13] The single-cone technique uses rotating Ni-Ti file systems and tapered gutta-percha, which is manufactured to be compatible with Ni-Ti files. This technique is advantageous due to its quick execution and simplicity.[14] Cold lateral condensation is a technique in which the main cone is placed in the root canal and the auxiliary cones are compressed into the canal using a spreader. Although this method is commonly used, it is time-consuming and can cause vertical root fractures due to the spreader used.[15] In the warm vertical compaction method, once the main cone has been placed in the canal, it is removed, leaving only the apical cone, then the root canal system is filled with thermoplastic injection and compacted using pluggers.[16]

In clinical applications, different types of root canal sealers can be used, such as epoxy resin, silicone, zinc oxide, methacrylate-based and calcium silicate-based root canal sealers. It has been reported that AH Plus Bioceramic (Dentsply Sirona, Charlotte, NC), a calcium silicate-based root canal sealer introduced in 2022, hardens rapidly, has high abrasion resistance and is more radiopaque compared to other root canal sealers.[17]

Various studies in the literature have reported that endodontic treatment success rates increase following lateral canal obturation.[1,5] For successful endodontic treatment, the entire root canal system must be effectively cleaned and filled.[8] Although the penetration capabilities of root canal sealers into lateral canals have been examined in several studies,[18-21] no previous research has focused specifically on how different obturation techniques influence the performance of AH Plus Bioceramic in this context. This study aims to evaluate and compare how deeply AH Plus Bioceramic root canal sealer penetrates lateral canals when different obturation techniques are employed. The null hypothesis of the study is that there is no difference in the penetration depth of AH Plus Bioceramic root canal sealer when different obturation methods are used.

Materials and Methods

Tooth Model Preparation

A total of 45 transparent and radiopaque 3D-printed maxillary lateral incisor models were fabricated by a commercial provider (Ancorax Software and Medical Devices, Ankara, Turkey). The models were produced via stereolithography from Anycubic Standard Clear resin and standardized to a length of 22 mm with an apical diameter of 0.30 mm. At the same time, the teeth had lateral canals with a diameter of 0.15 mm and a length of 3 mm at a distance of 3 mm from the apex (Figure 1). The 3D printed teeth were placed in polyvinyl silicone impression material (Hydrise Light, Zhermack, Italy) to replicate the alveolar socket.

Root Canal Instrumentation

The working length (WL) was determined to be 1 mm less than the total length of the canal. The root canal instrumentation was shaped with EndoArt Touch Gold (Inci Dental Productions Co, İstanbul, Türkiye) files up to size 35/.06 in accordance with the manufacturer's recommended protocol. Irrigation was performed with distilled water throughout the shaping process. To ensure patency, a #10 K-file was utilized in both the main and lateral canals.

The required sample size was determined based on prior studies evaluating lateral canal filling.[18,22-24] The specimens (n = 45) were randomly assigned into three equal groups of 15 teeth each, categorized by the obturation technique to be implemented. In all groups, obturation was carried out using AH Plus Bioceramic sealer and gutta-percha.

Group 1: Single Cone Technique

Gutta-percha (Diadent, Chongju, Korea) with a taper angle of 35/.06 was applied with AH Plus Bioceramic root canal filling sealer and placed in the WL of the root canal. Next, the remaining gutta-percha was cut off utilizing a heat conductor, after which the coronal area was condensed by means of a plugger (Figure 2a).

Group 2: Cold Lateral Condensation Technique

A 35/.02 taper master gutta-percha cone (Diadent, Chongju, Korea) was coated with AH Plus Bioceramic root canal filling sealer and applied in the root canal. A cavity 1 mm shorter than the WL was created in the root canal using a number 25 spreader. Auxiliary gutta-percha cones sized 25/.02 were inserted into the cavity prepared with the spreader. The process was continued until the spreader penetration into the root canal was limited to 2–3 mm (Figure 2b). Next, the remaining gutta-percha was cut off utilizing a heat conductor, after which the coronal area was condensed by means of a plugger.

Group 3: Warm Vertical Compaction Technique

A 35/.06 tapered gutta-percha cone was inserted into the root canal, positioned 1 mm short of the working length, and the tug-back was verified. The gutta-percha was subsequently lined with AH Plus Bioceramic sealer and inserted into the root canal. Vertical condensation was subsequently carried out using pluggers (Dentsply Maillefer, Ballaigues, Switzerland), and the remaining root canal space was obturated with gutta-percha via a thermoplastic injection system (Eighteeth Thermoplastic Gutta-Percha Injection System, Changzhou, China) (Figure 2c).

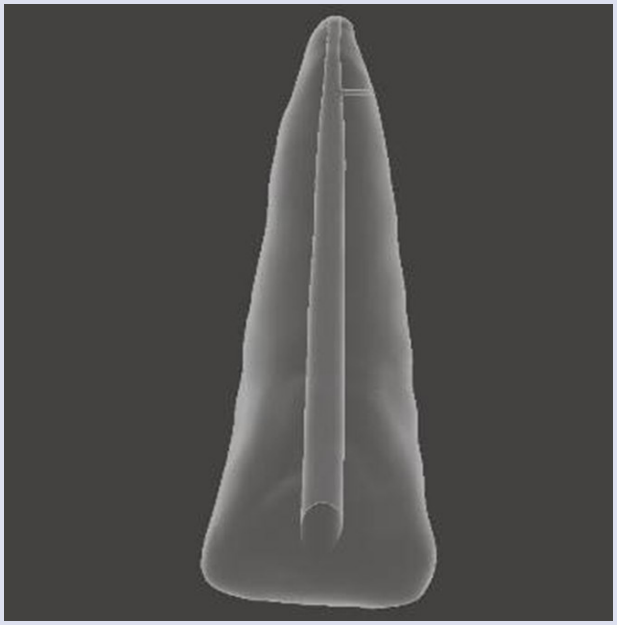


Figure 1. 3D-printed tooth radiographic image.

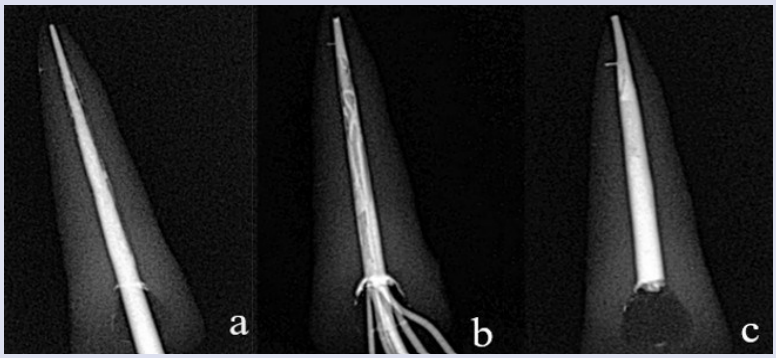


Figure 2. a) Single Cone Technique. b) Cold Lateral Condensation Technique. c) Warm Vertical Compaction Technique.

Radiographic Assessment and Scoring

Following obturation, radiographic images (BEST-X-AC, New Life Radiology, Verona, Italy) were taken using a digital radiography unit with exposure parameters set at 65 kV, 7 mA, and 0.08 seconds. The images were saved in JPEG format (Figure 3) and evaluated using a modified scoring system adapted from Arslan et al.[18]

- Score 0: No sealer detected in the lateral canal
- Score 1: Sealer filled less than half of the lateral canal
- Score 2: Sealer filled more than half of the lateral canal
- Score 3: Lateral canal completely filled

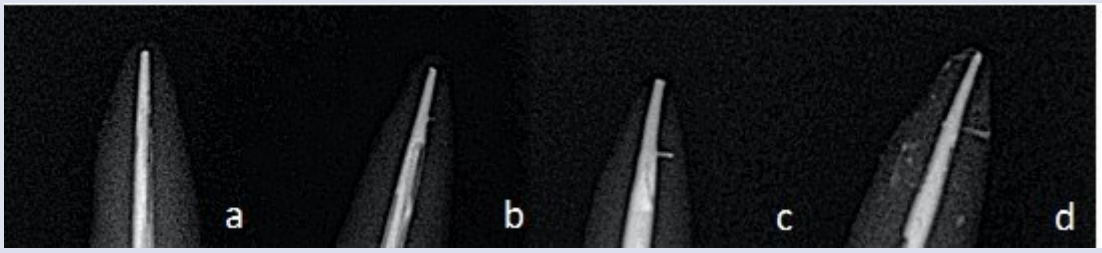


Figure 3. a-d Representative radiographic images corresponding to the scoring system: a) Score 0, b) Score 1, c) Score 2, d) Score 3.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA). The Kruskal–Wallis and Mann–Whitney U tests were applied, and results with $p < 0.05$ were considered statistically significant.

Results

Table 1 summarizes the average scores along with their respective standard deviations for each group. The choice of obturation technique was found to have a significant impact on the penetration of the root canal filling sealer into the lateral canals ($p = 0.002$). Specifically, the warm vertical compaction technique achieved greater penetration depth of the AH Plus Bioceramic root canal sealer into the lateral canals compared to both the single cone ($p = 0.001$) and cold lateral condensation ($p = 0.010$) methods. No statistically significant difference was noted between the single cone and cold lateral condensation techniques regarding penetration depth into the lateral canals ($p = 0.653$).

Table 1. Penetration score Means and Standard Deviations (SD) for each obturation technique

Obturation technique	n	Mean ± SD	*p* value
Single Cone	15	$0.6667^{a} \pm 0.9759$	0.001*
Cold Lateral Condensation	15	$0.9333^{a} \pm 1.2228$	0.010*
Warm Vertical Compaction	15	$2.2667^{b} \pm 1.1629$	-
Overall (Kruskal–Wallis)	-	-	0.002

Pairwise comparisons were performed using the Mann–Whitney U test. Superscript letters denote statistical significance: [a] = no statistically significant difference, [b] = statistically significant difference. (*) p-values shown for comparisons versus Warm Vertical Compaction.

Discussion

Studies have shown that filling lateral canals increases the success rate of root canal treatment.[5,19] The obturation technique selected plays a crucial role, as it influences the capacity to inhibit bacterial recolonization and prevent subsequent intraradicular reinfection.[8,20]

In the study, ready-made resin blocks with standardised dimensions of the main and lateral canals were used. In some studies, resin blocks were preferred over natural teeth in order to make standard comparisons.[21,25] In this study, commercially available resin blocks with uniform dimensions of main and lateral canals were utilized.[26] Despite the ease of creating narrow branches in resin blocks, the different surface structures of resin blocks compared to natural teeth may affect the handling characteristics of gutta-percha and sealer.[21,26] Therefore, there are some limitations to using resin blocks instead of natural teeth.[21] One of the limitations of the resin blocks used is that the surface texture of the blocks differs from that of dentin in terms of texture and hardness. This difference may have affected the penetration of the AH Plus Bioceramic sealers used in the lateral canals.

AH Plus Bioceramic root canal sealer, which is a premixed calcium silicate-based sealer, represents a recent advancement in root canal obturation materials. Although research on this material remains limited, available studies have explored its key physicochemical attributes, including flow characteristics, solubility, antibacterial efficacy, and cytocompatibility.[17,27,29] Its formulation is designed to enhance clinical handling while maintaining biological safety.

According to the results of the present study, the obturation technique alters the penetration of root canal sealer into lateral canals. The warm vertical compaction method penetrated lateral canals with a statistically significantly higher depth than those of the cold lateral condensation and single cone methods. Therefore, the null hypothesis of the study was rejected. Thermoplastic obturation methods, particularly warm vertical compaction, have been shown to produce more homogeneous and three-dimensionally sealed root canal fillings. Although cold lateral condensation continues to be widely implemented in clinical settings, existing evidence suggests it may lead to the formation of voids and suboptimal adaptation to canal walls.[30,31] Schilder et al. [1] reported that lateral canals can be routinely filled with the warm vertical compaction method. In the study, it was observed that when the warm vertical compaction method was applied, the sealer penetrated the lateral canals better than other obturation methods. Wolf et al.[32] reported that warm vertical compression achieved better lateral canal filling than cold lateral condensation in resin-based models, which corroborates the findings of this study. Brothman et al.[33] analysed the obturation of lateral canals radiographically in their studies. They found that the warm vertical compression method was more successful than the cold lateral condensation method. Juha et al.[34] evaluated the

penetration of BC Sealer HiFlow sealer into the lateral canals of mandibular premolars using CBCT and the obturation techniques which were used in the present study. In contrast to the results of the present study, they reported that the penetration of the sealer into the lateral canals was comparable following the application of both cold lateral condensation and warm vertical compression techniques. They concluded that the penetration depth of the sealer into the lateral canals was at least as great as with the single cone method. The variation in findings across studies is thought to arise from factors including the choice between resin blocks and natural teeth and the type of canal filling material used. The long-term clinical effects of AH Plus Bioceramic sealer are unknown in the current literature. Although this study evaluated the clinical usability of this sealer with different obturation techniques, the results obtained cannot be directly applied clinically.[38] This is because the sealer used may not be able to penetrate the lateral canals clinically due to various factors such as the hardness and thickness of the dentine, the diameter of the lateral canals, and pulp tissue remnants.

Conclusions

Within the limitations of the present study, it can be concluded that the warm vertical compaction method significantly improved the penetration of the sealer into the lateral canals. Further studies are warranted to explore the penetration characteristics of this sealer and to compare its performance with other bioceramic and conventional sealers under different clinical and laboratory conditions.

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None.

Conflicts of Interest Statement

Since this study is an in vitro study using 3D-printed teeth, no formal informed consent was required. There were no conflicts of interest

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