



Evaluation of Calcium Hydroxide Root Canal Filling Materials by Cone Beam Computed Tomography and Three-Dimensional Modeling

Asel Usdat Ozturk¹, Ekin Dogan², Venus Seyedoskuyi², Berk Senguler², Asli Topaloglu-Ak²

¹ Oral and Maxillofacial Radiology Department, Faculty of Dentistry, Istanbul Aydin University, Istanbul, Türkiye

² Istanbul Aydin University, School of Dentistry, Pedodontics Department, Istanbul, Türkiye

Corresponding author: Asli Topaloglu-Ak, Istanbul Aydin University, Istanbul, Türkiye; Email: asliak@aydin.edu.tr

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Abstract

Aim: The aim of this study was to compare the effectiveness of filling pastes in resin prototype primary molars by cone beam computed tomography (CBCT) and 3D modeling.

Materials and methods: The canals of 27 primary second molar teeth models were shaped with a rotary endodontic motor to file No. 30/04. The samples were randomly divided into three groups and filled with calcium hydroxide-distilled water, Viopex, and calcium hydroxide-propylene glycol, respectively (n=9). Pre-filling and post-filling CBCT images of the shaped canals were obtained, 3D models were reconstructed with MiMiCS[®] software and volume measurements were made in cubic millimeters (mm³). Differences between the volume of the shaped canals and filling materials were calculated as the miss-filling areas of various filling materials were also recorded. Dependent 2-group I-test, Bonferroni test, and one-way analysis were used for statistical analysis. Data were statistically analyzed at $p < 0.05$ significance level by IBM SPSS 25 software.

Results: Among the three root canal sealers, the filling capacity of the calcium hydroxide-propylene glycol group was found to be the highest ($p=0.001$).

Conclusion: When calcium hydroxide mixed with propylene glycol was compared to calcium hydroxide alone, calcium hydroxide demonstrated a greater potential for root canals in primary maxillary second molar models. It is clear that clinical studies with follow-ups of the subjects will contribute to literature and clinical success.

Keywords

miss filling, primary molar teeth, root canal filling

INTRODUCTION

Endodontic treatment in primary teeth aims to preserve the teeth's integrity and health, as well as the periodontal and periapical tissues, until they are replaced by permanent teeth. Comprehensive cleaning and filling of the root canal system is essential to prevent bacterial infection and toxins. However, it is claimed that a lack of understanding of pulp

anatomy is the cause of root canal failure.^[1-3] The filling material must reach and fill the entire root canal in three dimensions, providing a biocompatible seal.

Furthermore, the root canal system in primary teeth has unique characteristics that make complete sealing difficult. Gomes et al. found that anatomical changes such as collateral or lateral canals and apical delta within the root canal significantly affect the success of root canal treatment. If an

existing excess canal is overlooked, the treatment prognosis will be adversely affected.^[4]

Various filler materials and techniques have been aimed at increasing the chances of successful root canal treatment in primary teeth. Zinc oxide eugenol, calcium hydroxide, and iodoform fillers are commonly used and recommended, but no material has yet been accepted as a gold standard.^[5,6] Hence, the canal filling potency of root canal pastes continues to be of interest to researchers. Apex reachability, filled root canal volumes, and the presence of miss-fillings are some of the evaluation criteria to assess the success of root canal fillings.^[7,8]

AIM

Thus, the present study aimed to compare the filling capacities of calcium hydroxide-based root canal sealers by using cone beam computed tomography (CBCT) images and three-dimensional modeling of root canals of primary maxillary second molar models.

MATERIALS AND METHODS

The study was conducted using commercially available prototypes of primary molar teeth containing root canals. The use of these prototyped resin replicas has the potential to be used for educational purposes, endodontic training, and research due to the sample standardization.

Twenty-seven polymer-based prototype upper primary second molar teeth were fixed on wax and shaped by a rotary endodontic motor and endoart Pedo blue nickel titanium files. 18-mm 15/06, 25/04, and 30/04 files were used according to the recommendation of the manufacturer's protocol. At each file change, irrigation was provided with the saline solution using a perforated needle. After the irrigation process, the canals were dried with paper points. All samples were divided into three equal groups according to the filling materials: G1 - calcium hydroxide-distilled water, G2 - injectable calcium hydroxide-iodoform mixture (Viopex), and G3 - calcium hydroxide-propylene glycol.

Equal amounts of calcium hydroxide paste with three different carriers were placed in the root canals. The calci-

um hydroxide pastes were prepared as follows: one scoop of calcium hydroxide powder and one drop of distilled water (G1), one scoop of calcium hydroxide powder, and one drop of propylene glycol (G3) were mixed in a 1:1 ratio of powder and liquid on a mixing paper. These mixtures were prepared fresh and sent to the canals by a Lentulo spiral. Finally, Viopex (G2) was applied to its own syringe until it overflowed from the canal orifices. The cavity was cleaned with cotton pellets and restored with glass ionomer cement and CBCT images were re-obtained.

CBCT images were obtained from shaped root canals before and after filling both in the same position and protocol. In order to standardize the positions of the teeth, groups were identified with a marker on the anterior side of the block and a number was given for each block. All CBCT images were obtained by the same operator with Moritta® 3D Accuitomo 170, J. Morita MFG. CORP, Tokyo, Japan (Moritta®) CBCT device in 0.8 mm³ isotropic voxels and 0.480 mm slice thickness. The operating parameters were 90 kVp, 2.5 mA, and 30.8 s, the field of view (FOV) was 4×4 cm², and images were obtained in the high-resolution imaging mode. The device delivers each irradiation with a single 360° rotation around the model. The images obtained were saved in Digital Imaging and Communications in Medicine (DICOM) format. 3D reconstructions of the shaped canals and filling materials, from the isthmus to the apex of the roots, were done with the MiMiCS® software, and their volumes were calculated in mm³ (Fig. 1).

A single researcher performed all evaluations, and 15 randomly selected CBCT images were re-evaluated four weeks later for intra-observer reliability assessment. The intraclass correlation coefficient (ICC) was used to investigate the consistency between measurements in quantitative data. In terms of the study's objectivity, the researcher who made the measurements differed from the researcher who worked on the models.

The data were analyzed statistically, and the success of intracanal filling of three different calcium hydroxide pastes were evaluated. SPSS 25 (IBM Corp. Publication. 2017 IBM SPSS Statistics, Version 25.0. Armonk, NY: IBM Corp.) statistical package was used to analyze the data. Mean ± standard deviation, percentages, and frequency values are used. Variables were evaluated for normality and homogeneity of variances after prevaccination control

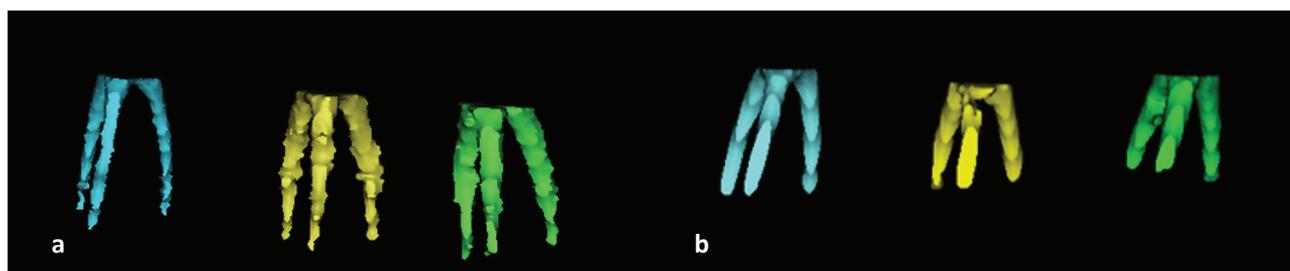


Figure 1. 3D reconstruction of a group of polymer-based prototype upper primary second molar teeth root canals, a) shaped root canals, b) filled root canals.

(Shapiro-Wilk and Levene tests). While performing data analysis, Bond 2 group *t*-test (pairing surplus test) was used for the comparison of two groups, and one-way analysis of variance and comparison test were evaluated by Bonferroni test for further group comparison. Intra-class correlation (ICC) for inter-measure agreement. The $p < 0.05$ and $p < 0.01$ values were accepted for the significance level of the tests.

RESULTS

The aim of this study was to compare the filling effectiveness and internal voids of different obturation materials in polymer prototyped primary molars. Intraclass correlation coefficient (intrakappa value) was high, with a value of 99.8%, indicating an agreement between the first and second measurements of the same root canal volume (Table 1). There was a statistically significant difference between the empty and filled canal volumes in the calcium hydroxide-distilled water, Viopex, and calcium hydroxide-propylene glycol groups. The calcium hydroxide-propylene glycol group showed the highest filling success ($p=0.001$), followed by Viopex group ($p=0.011$). Calcium hydroxide-distilled demonstrated the least filling capacity of root canals ($p=0.014$) (Table 2).

DISCUSSION

Researchers have focused on developing new root canal pastes to overcome the filling difficulties due to miss-filling or overfilling.^[7-9] In dental literature, there are limited data on the filling effectiveness of calcium hydroxide in primary teeth when used by different carriers.^[10] In this study, CBCT imaging and 3D modeling were used to evaluate the

filling capacity of calcium hydroxide based filling materials with different carriers namely distilled water, propylene glycol, and iodoform.

The present study used polymer-based prototype primary molars that ensured standardization by eliminating different results due to different root canal anatomies and physiological root resorptions. However, since the interaction between dentin and canal sealer cannot be evaluated in polymer teeth, results may differ in vivo.

Some studies have used radiography as an evaluation method, resulting only in two-dimensional interpretation.^[11,12] In the present study, CBCT was used to assess the filling capacity of root canal pastes. CBCT uses cone-shaped X-ray to acquire data by revealing root canal morphology in a single 360° rotation. Compared to computed tomography (CT), CBCT provides improved accuracy, low scanning time, low radiation doses, and high resolution.^[13]

For standard enlargement, pediatric files were used with rotary endodontic motor movement. In addition, 15/06, 25/04, and 30/04 taper files were used by a single operator. Samples with the same canal anatomy made the technique reproducible and the results consistent.

In this study, calcium hydroxide-distilled water and calcium hydroxide-propylene glycol mixture were applied with lentulo, while Viopex was applied with its syringe in compliance with the manufacturer's recommendations.

In another study, zinc oxide eugenol paste was applied to the canals with lentulo and injector. Lentulo showed the best results in reaching the apex, while the injector filled the intracanal volume the best.^[11]

In dental literature, there are a limited number of studies with different evaluation criteria, which makes the results incomparable. For example, some assess the reaching apex, while some evaluate the void presence.^[12-15] Furthermore,

Table 1. Intra class correlation coefficient test

	Intraclass correlation	95% Confidence interval		<i>p</i>
		Lower bound	Upper bound	
Average measures	0.998	0.992	0.999	0.001

99.8% correspondence between first and second shaped canals measurements.

Table 2. Filling success of different materials

Group		Mean	SD	<i>P</i>
KALSIYUM HIDROKSIT-DISTILE SU	Shaped canal volume	23.34	3.26	0.014*
	Filling material volume	19.77	1.12	
VIOPEX	Shaped canal volume	23.06	1.92	0.011*
	Filling material volume	21.06	3.46	
KALSIYUM HIDROKSIT-PROPILEN GLIKOL	Shaped canal volume	25.48	1.27	0.001*
	Filling material volume	23.03	2.19	

Paired t test, $p < 0.05$

since different filling techniques and different canal sealants are used, the designs of the studies also vary.

Walia et al. designed their study on 45 extracted teeth separated into three groups calcium hydroxide + iodoform with a syringe, zinc oxide eugenol paste using rotary lentulo, and handheld lentulo.^[15] Apex reachability of pastes were assessed by radiographic examination. The syringe method demonstrated overfilling, whereas both lentulo techniques showed better-filling quality.

Miss-filling areas in the canal can cause microleakage and lead to reinfection. Hence, selecting the appropriate root canal paste in clinical practice assists in the avoidance of this formation.^[16,17]

CONCLUSION

The results of this study suggest that when calcium hydroxide is mixed with propylene glycol it shows a higher canal filling success compared to distilled water and iodoform mixtures.

Future studies should focus on studying extracted teeth with great sample numbers to reveal differences between filling materials. In addition, further clinical studies should be conducted for both primary and permanent teeth to confirm the results.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Оценка материалов для пломбирования корневых каналов на основе гидроксида кальция с помощью конусно-лучевой компьютерной томографии и трёхмерного моделирования

Асел Усдат Озтюрк¹, Екин Доган², Венус Сейедоскуй², Берк Сенгулер², Асла Топалоглу-Ак²

¹ Кафедра оральной и челюстно-лицевой радиологии, Факультет стоматологической медицины, Стамбульский университет Айдын, Стамбул, Турция

² Стамбульский университет Айдын, Факультет стоматологической медицины, Кафедра детской стоматологической медицины, Стамбул, Турция

Адрес для корреспонденции: Асла Топалоглу-Ак, Стамбульский университет Айдын, Стамбул, Турция; Email: asliak@aydin.edu.tr

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Резюме

Цель: Целью данного исследования было сравнение эффективности пломбировочных паст в прототипах временных моляров из смолы с помощью конусно-лучевой компьютерной томографии (КЛКТ) и 3D-моделирования.

Материалы и методы: Каналы 27 моделей молочных вторых моляров были сформированы с помощью роторного эндодонтического двигателя с напильником № 30/04. Образцы были случайным образом разделены на три группы и заполнены дистиллированной водой гидроксида кальция, Viorex и гидроксидом кальция-пропиленгликолем соответственно (n=9). Были получены КЛКТ-изображения сформированных каналов до и после пломбирования, 3D-модели были реконструированы с помощью программного обеспечения MiMiCS®, а измерения объёма были выполнены в мм³. Различия между объёмом сформированных каналов и пломбировочными материалами рассчитывались по мере того, как фиксировались площади незаполнения различными пломбировочными материалами. Для статистического анализа использовались зависимый 2-групповой I-тест, тест Bonferroni и односторонний анализ. Данные статистически анализировали при уровне значимости $p < 0.05$ с помощью программного обеспечения IBM SPSS 25.

Результаты: Среди трёх герметиков для корневых каналов наполняющая способность группы гидроксида кальция и пропиленгликоля оказалась самой высокой ($p=0.001$).

Заключение: При сравнении гидроксида кальция, смешанного с пропиленгликолем с чистым гидроксидом кальция, гидроксид кальция продемонстрировал больший потенциал при заполнении корневых каналов на моделях первичных вторых моляров верхней челюсти. Очевидно, что клинические исследования с последующим наблюдением за субъектами будут способствовать увеличению числа публикаций и клиническому успеху.

Ключевые слова

неправильное пломбирование, молочные коренные зубы, пломбирование корневых каналов