Dental Research Journal

Original Article

The effect of the gap between the cast post and residual gutta-percha and cement type on microleakage of endodontically treated teeth using the fluid filtration method

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ABSTRACT

Background: The aim of this study was to investigate the impact of the distance between the gutta-percha and the post, as well as the type of cement used, on the incidence of microleakage in endodontically treated teeth.

Materials and Methods: This experimental-laboratory study involved 72 single-canal, single-rooted teeth, which were randomly sorted into six study groups and two control groups, each containing nine teeth. The six groups were further divided based on the distance between gutta-percha and post (0 mm, 0–2 mm, and >2 mm) and then categorized by cement type into glass ionomers and resins. Microleakage was evaluated using the fluid filtration method at 15 and 30 days. Data were analyzed using SPSS software, employing between-subjects effects and *post hoc* Tukey tests at a 5% significance level.

Results: Cement type did not significantly affect microleakage ($P = 0.598$). However, microleakage increased significantly with larger gaps between the post and remaining gutta-percha ($P = 0.002$). No significant difference in microleakage was observed between the gapless and ≤2 mm groups ($P = 0.328$). Similarly, ≤2 mm and >2 mm groups did not show any notable difference ($P = 0.054$). However, the difference in microleakage between the gapless group and the ≥2 mm gap group was significant ($P = 0.001$).

Conclusion: This study found no significant difference in microleakage between glass ionomers and resin cements. Only gaps >2 mm significantly affected microleakage.

Key Words: Dental cements, dental leakage, endodontically treated teeth, fluid filtration, root canal therapy

Received: 12-Sep-2024
Revised: 15-Dec-2024
Accepted: 06-Jan-2025
Published: 19-Mar-2025

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INTRODUCTION

Cast posts and cores are employed when teeth have experienced a significant loss of tooth structure and

Access this article online

Website: www.drj.ir
www.drjjournal.net
www.ncbi.nlm.nih.gov/pmc/journals/1480
DOI: 10.4103/drj.drj_418_24

How to cite this article: Mosharraf R, Farahmand S, Arzani S, Hemati H, Abolhasani M, Golshirazi B, *et al*. The effect of the gap between the cast post and residual gutta-percha and cement type on microleakage of endodontically treated teeth using the fluid filtration method. Dent Res J 2025;22:11.

are unable to adequately support and retain crown restorations.[1] The success of root canal therapy can be compromised by leakage from the oral environment into the canal.[2] A space between gutta-percha and post provides an ideal environment for bacterial growth, which can adversely affect the success of endodontic treatment.[3] According to Torabinejad *et al*., contamination of the coronal part of the canal filling with bacteria and their endotoxins can potentially lead to their penetration and transfer to the apical foramen within 3 weeks.[4] Even it has claimed that root canal treatments are more likely to fail due to coronal leakage than apical leakage.[5] The occurrence of leakage can be influenced by various factors, such as the quality of obturation, the technique, the rigidity of post, the type of cement used, and the timing of postspace preparation.[6-8]

It is assumed that the minimum amount of gutta-percha remaining at the end of the canal to maintain the apical seal should be 3 mm, but it is preferable to let 6 mm of gutta-percha remain in the canal.[3,9] However, even leaving 7 mm of gutta-percha has less sealing than an intact filling.[10] It is not uncommon to observe a gap between the posts used in teeth and the remaining gutta-percha.[3,11] This empty space can be caused by errors during the impression-taking process or shrinkage in the alloy during casting. It is crucial for the canal filling to create a complete seal to prevent the penetration of microorganisms, but the presence of this empty space between the gutta-percha and the post undermines this essential requirement. Endodontic treatment success is greatly affected by the distance between the remaining gutta-percha and the post.[12-14]

A cement's properties can affect its ability to seal gaps between posts and gutta-percha.[14] A number of studies have also shown that luting agents differ significantly in their ability to reduce microleakage between the cement and tooth structure.[15-19] Resin cements, glass ionomers, zinc phosphate, and zinc polycarboxylate are various types of luting agents commonly used for cementing posts. Each of these agents has distinct chemical and mechanical properties that influence their bonding capabilities to tooth structure.[20] These variations can impact the amount of microleakage observed. The aim of this study was to assess the impact of the distance between the gutta-percha and the post, as well as the type of cement used (glass ionomer or resin cement), on microleakage.

MATERIALS AND METHODS

In this experimental-laboratory study, 72 single-rooted and single-canal teeth with fully formed roots were extracted due to orthodontics, prosthetics, periodontal problems, or caries, and were donated by the patients and with full consent to use them for research. This research was investigated in the Dental Materials Research Centre of the Isfahan Dental Faculty and the Mashhad Dental Faculty, and under the code of ethics (IR.MUI.RESEARCH.REC.1402.026), ethical clearance was obtained.

The inclusion criteria were single root and single canal teeth without extensive caries or extensive restoration with an approximate length of 20–22 mm. Teeth with a prosthetic crown, root fracture, open apex, degree of curvature >10–20 degrees (using the method described by Schneider),[21] presence of more than one canal, presence of canal calcification, or internal and external resorption were excluded. The sample size was calculated at a significance level of 5% (α = 0.05), with a test power of 80% (β = 0.2), according to the study of Al-Madi *et al*.[14] A total of 72 samples were included in this study, divided into eight experimental groups, with each group consisting of nine teeth. The sample selection was conducted using a simple random method, aided by a random number table.

The root surfaces were cleaned by Curette (Universal curette, Columbia 13–14, ASA Dental) and all of them were kept overnight in 5.25% hypochlorite solution for disinfection. For standardization, the crown of all teeth was shortened to 2 mm of cementoenamel junction by a diamond disc (Diaflex, 0.5 mm, Horico). Subsequently, the teeth underwent root canal therapy, during which a #15 k-file (25 mm, Mani) was used to visually determine the working length.

The cleaning and shaping were carried out using the rotary E Connect Pro system and a passive step-back technique. Throughout the process, the canal was irrigated with a 5.25% sodium hypochlorite solution (Hypo-EndOX Sodium hypochlorite, Morvabon). After drying the canal by paper points, it was obturated with 2% taper gutta-perchas (Meta Gutta Percha Points, Meta-Biomed) and AH26 root canal sealer (AH26 Silver Free Sealer, Dentsply) with lateral condensation technique. The quality of treatment was evaluated using radiography. Postspace was prepared using Peeso Reamers of sizes 2 and 3

(Mani Peeso Reamer, 32 mm, Stainless Steel, Mani). In all cases, 5 mm of gutta-percha was left remaining. A post pattern was then fabricated, and a 3 mm core was constructed for each tooth. The resin posts and cores were cast by nickel–chromium alloy, and their fit to the canals was checked using fit checker. If any post did not fit the canal properly, the mentioned steps were repeated.

The teeth were randomly divided into eight groups [Table 1], consisting of six experimental groups and two control groups (n = 9). The experimental groups were categorized into three based on the gap between the gutta-percha and the post. The first group included teeth with no gap between the gutta-percha and the post (no spacing). The second group consisted of teeth with a distance of 0–2 mm between the post and gutta-percha (≤2 mm spacing), while the third group included teeth with a distance >2 mm (>2 mm spacing).[3,12]

Before cementing the posts, those requiring a specific gap had their ends shortened using a diamond disc (Diaflex, 0.5 mm, Horico). Each of these three categories was further divided into two groups based on the type of cement: glass ionomer and resin. If any casting defects were observed, the post was removed, and a new post was created. Cementation was performed according to the manufacturer's instructions for each product.

To prepare the samples, except for the control groups, the external surface of the teeth was covered by two layers of nail polish, except for 2 mm of the apical surface.[22] In the negative control group, the entire surfaces of the teeth up to the apical end were covered with two layers of nail polish to prevent any leakage and microleakage of liquid. In the positive control group, no surface was covered by nail polish to ensure that all pathways of the root canal system were open. All teeth were then placed in an incubator at 37°C and 99% humidity for a week.

Microleakage was assessed using the fluid filtration method. Figure 1 provides a schematic example of the microleakage process.[23] A 15-day and 30-day examination of all teeth was conducted for the detection of microleakage.

The analysis in this study was conducted at both descriptive and inferential levels. Descriptively, frequency indicators and percentages were used for qualitative variables, while average indicators and standard deviation were reported for quantitative variables. On the inferential level, between-subjects effects tests were used to examine the effects of each of the two variables. In addition, *post hoc* Tukey's tests were conducted to compare groups pairwise. The data obtained from this study were analyzed using SPSS software version 26 (developed by IBM Corporation in Armonk, New York, United States) and ANOVA statistical test at the 5% error level.

RESULTS

The mean and standard deviation of microleakage in different groups of this study are given in Table 2. According to the values in Table 3, the type of cement has no effect on the amount of microleakage (P = 0.598), while the amount of microleakage increases significantly with the increase of the distance between the post and the remaining gutta-percha (P = 0.002). This increase is not affected by the type of cement (P = 0.243). According to *post hoc* Tukey's

Table 1: Classification of study groups

Group number	Group name
1	Resin cement, no spacing
2	Resin cement, ≤2 mm spacing
3	Resin cement, >2 mm spacing
4	Glass ionomer cement, no spacing
5	Glass ionomer cement, ≤2 mm spacing
6	Glass ionomer cement, >2 mm spacing
7	Positive control
8	Negative control

Table 2: Mean and standard deviation of microleakage in terms of μL/min/cm³ H_2O in the studied groups

Group number	Mean	SD
1	0.64	0.26
2	0.78	0.16
3	0.89	0.33
4	0.57	0.07
5	0.73	0.39
6	1.15	0.48

SD: Standard deviation

Table 3: The effect of the type of cement and the distance between the post and the remaining gutta on the amount of microleakage

Variable	F	P
Type of cement	0.28	0.598
The distance between the post and the remaining gutta	7.54	0.002
Type of cement × distance between the post and the remaining gutta	1.46	0.243

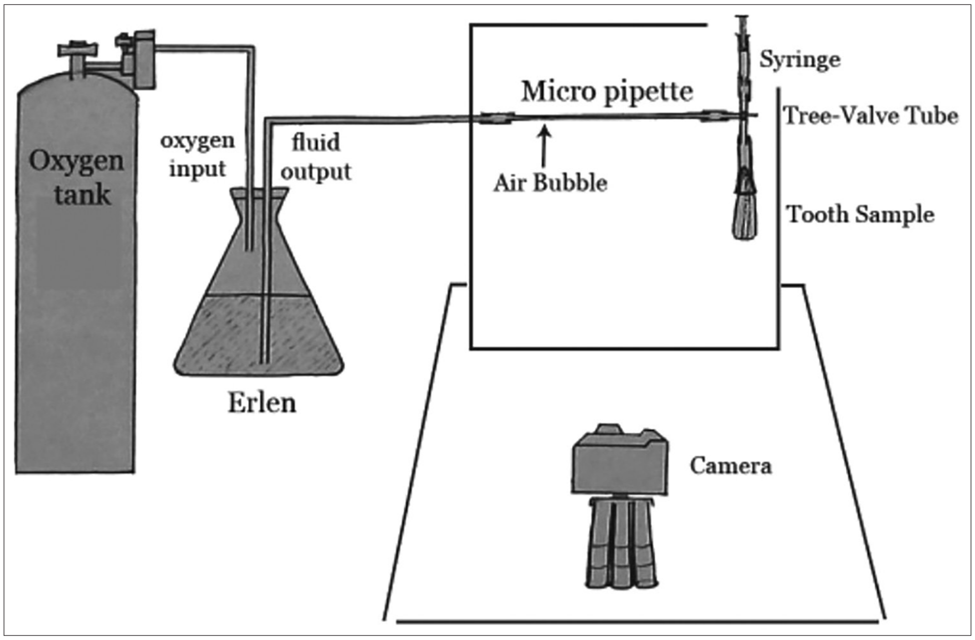

Figure 1: Schematic view of the microleakage process (Courtesy to Javidi *et al.*[23]).

test, there was no significant difference between the distance 0 and <2 mm ($P = 0.328$) and between <2 mm and more than 2 mm ($P = 0.054$), but the amount of microleakage in the absence of a gap and at a gap of more than 2 mm differs significantly ($P = 0.001$). The amount of microleakage was higher at a distance of more than 2 mm [Table 4].

DISCUSSION

It has been demonstrated in recent studies that leakage from the oral environment to the root canal is an important determinant of the success of endodontic treatment and the development of periapical pathosis.[2] This study investigated the effect of the gap between gutta-percha and post and the type of cement on endodontically treated tooth microleakage. The findings of our study revealed that there was no significant difference in microleakage between glass ionomers and resin cements. Moreover, the distance between the post and the gutta-percha caused a difference in microleakage only if the distance was >2 mm.

Similarly to the present study, Moshonov *et al.*[12] investigated microleakage between gutta-percha and the posts at gaps of 0 mm, <2 mm, and >2 mm. They concluded that complications are more likely to happen when there is a greater distance between gutta-percha and the post.

Ozkurt *et al.*[13] conducted a study in 2010 demonstrating the significant impact of the distance between the residual gutta-percha and the post on the success of endodontic treatments. However, in their study, the specific size of the gap was not investigated, and the teeth were categorized solely based on the presence or absence of a gap. Our results support those of Ozkurt *et al.*, who noted that gaps should be taken into consideration when assessing endodontic treatment success.

In 2018, Al-Madi *et al.*[14] conducted a study using glucose infiltration and spectrophotometry that showed that a gap of 2–3 mm between gutta-percha and the post further increases the incidence of microleakage. The gap-time interaction was also investigated and was shown to be significant. In addition, they found that none of the zinc phosphate or resin cements could stop microleakage. They stated that filling the gap with gutta-percha significantly reduced microleakage. As a result of the limitations of our study, the effect of time was not investigated; however, as Al-Madi *et al.* found, a distance of more than 2 mm between the gutta-percha and the post resulted in greater microleakage.

A 4-year follow-up study by Sayed *et al.*[24] concluded that the coronal end of the remaining gutta-percha should be cemented in contact with the apical end of the post, which is consistent with the current study's results. They also noted that a gap between the apical end of the post and the coronal section of gutta-percha increases the likelihood of an unhealthy periapical condition, bone loss, and periodontitis.

Table 4: Comparing the amount of microleakage at different distances between the post and the remaining gutta 2 × 2 between groups

Distance comparison	Mean difference	SE	*P*
0 and <2 mm	−0.16	0.11	0.328
<2 mm and more than 2 mm	−0.26	0.11	0.054
0 and more than 2 mm	0.42	0.11	0.001

SE: Standard error

Studies have compared the microleakage of various cements and have consistently found that zinc phosphate and polycarboxylate cements exhibit the highest levels of microleakage. In contrast, resin cements and glass ionomer cements demonstrate significantly lower levels of microleakage, which makes them more reliable.[20,25] Bachicha *et al*.[26] reported in a study that bonding cements exhibit less microleakage than nonbonding cements.

Albert *et al*.[15] stated that glass ionomer is more prone to microleakage than resin cement. However, in the present study, glass ionomer and resin cement did not show any significant difference in terms of leakage rate. This difference in results can be caused by the different procedures and limitations of each study.

To further validate the findings of this study, future research should include a larger sample size of teeth and extend over a wider period. In addition, it is recommended to include teeth with varying degrees of curvature to obtain a comprehensive understanding of the relationship between gap distance and treatment outcomes.

CONCLUSION

It can be concluded from the results of this study that the treatment is more likely to succeed with less amount of leakage when there is no gap between gutta-percha and post. By contrast, a gap >2 mm significantly reduces treatment success. Moreover, this study did not find a significant difference between glass ionomer and resin cement in terms of microleakage.

Financial support and sponsorship
Nil.

Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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