Comparison of Apical Leakage in Root Canals Obturated with Various Gutta-Percha Techniques¶

FARKLI GUTTA PERKA TEKNİĞİ İLE DOLDURULMUŞ KÖK KANALLARINDA APİKAL SIZINTISININ KARŞILAŞTIRILMASI

Necdet ADANIR*, Ali ERDEMİR**, Ayçe ÜNVERDİ ELDENİZ***, Sema BELLİ****

* Research Fellow, Department of Endodontics, Faculty of Dentistry, Süleyman Demirel University, ISPARTA
** Assistant Professor, Department of Endodontics, Faculty of Dentistry, Kırıkkale University, KIRIKKALE
*** Research Fellow, Department of Endodontics, Faculty of Dentistry, Selçuk University,
**** Associate Professor and Chair, Department of Endodontics, Faculty of Dentistry, Selçuk University, KONYA

Summary

Purpose: The aim of this in vitro study was to compare apical leakage of four root canal obturation techniques; laterally condensed gutta-percha technique, thermoplasticized gutta-percha on a carrier technique (Thermafil), thermoplasticized injectable gutta-percha technique (Ultrafil) and halothane dipped gutta-percha technique.

Material and Methods: Sixty one extracted single rooted human premolar teeth were used. The coronal part of each tooth was removed at the apical 17 mm of roots and the canals were instrumented with nickel-titanium Profile® .06 taper ISO series rotary instruments. The specimens were randomly divided into four of 15 samples each, filled with AH Plus using four different root canal obturation technique written above. A fluid filtration method was used for quantitative evaluation of apical leakage. The leakage was measured by the movement of an air bubble in a capillary glass tube connected to the experimental root sections. Fluid movement were measured at 2 minute intervals for 8 minutes. The quality of the obturation of the each specimen was measured after 7 days.

Results: Statistical analysis showed that; there was no significant difference among the groups obturated with lateral condensation, thermoplasticized gutta-percha on a carrier (Thermafil) and halothane dipped gutta-percha techniques ($p > 0.05$). However, with the thermoplasticized injectable gutta-percha (Ultrafil) technique, there was more leakage when compared to the other groups ($p < 0.05$).

Conclusion: Through use of these techniques in vitro, Thermafil, halothane dipped technique and traditional lateral condensation technique were found to be superior to the Ultrafil technique in terms of apical leakage.

Key Words: Apical leakage, obturation technique, fluid transport method

Özet

Amaç: Bu in vitro çalışmanın amacı, dört farklı kök kanal dolgu tekniğinin lateral kondensasyon tekniği, taşıyıcılı termoplastik gutta-perka tekniği (Thermafil), termoplastik gutta perka enjeksiyon tekniği (Ultrafil) ve halotene daldırılmış gutta perka tekniği apikal sızıntısını karşılaştırmaktı.

Materyal ve Metod: Çalışmada 61 adet tek köklü insan küçük azı dişi kullanıldı. Herbir dişin kuronal kısmı apikalden 17 mm uzunlukta olacak şekilde kesildi ve nikel-titanyum Profile® .06 taper ISO serisi eğeler ile kök kanallarının preparasyonu yapıldı. Örnekler herbirinde 15 adet olacak şekilde 4 gruba ayrılıp, AH Plus kanal dolgu patı kullanılarak yukarıda belirtilen tekniklerle kök kanal dolgusu yapıldı. Apikal sızıntının nicel değerlendirmesi için sıvı filtrasyon yöntemi kullanıldı. Sızıntı, örneklere bağlanmış olan mikropipet içerisindeki hava kabarcığının hareketi ile ölçüldü. Sıvı hareketinin ölçümü 2 dakika aralıklarla toplam 8 dakikada yapıldı. Ölçümler kanal dolgusu yapıldıktan 7 gün sonra yapıldı.

Bulgular: İstatistiksel analizler, lateral kondensasyon, taşıyıcılı termoplastik gutta-perka tekniği (Thermafil), ve halotene daldırılmış gutta perka tekniği arasında anlamlı bir fark olmadığını gösterdi ($p > 0.05$). Bununla beraber, termoplastik gutta perka enjeksiyon tekniği (Ultrafil), diğer gruplara göre daha fazla sızıntı gösterdi ($p < 0.05$).

Sonuç: Kullanılan bu in vitro tekniklerden Thermafil, halotene daldırılmış gutta perka tekniği ve geleneksel lateral kondensasyon tekniği apikal sızıntı açısından Ultrafil tekniğinden daha iyi bulundu.

Anahtar Kelimeler: Apikal sızıntı, kanal dolgu tekniği, sıvı filtrasyon yöntemi

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Hermetic obturation of the root canal system is assumed to be an important goal in endodontic treatment (1). To achieve this, root canal fillings must have seal the pulpal space apically, laterally and coronally to prevent possible further apical irritation from incomplete elimination bacterial products or continuous communication between apical tissues and the oral cavity. The root canal system often possesses a complex anatomy, including fins, isthmi, ramifications, and other irregularities. It has been claimed that many of these areas were difficult to fill by using conventional techniques (2). Many techniques and materials have been used to obturate anatomically complicated root canal space. For decades, gutta-percha has been considered the most adaptable and compatible core material for root fillings (3). Presently, lateral condensation of gutta-percha, a variety of heat-softened gutta-percha and dissolved gutta-percha with chemical solvents such as chloroform or halothane filling techniques were commonly used obturation techniques.

In 1977, Yee et al. (4) introduced the injection-molded thermoplasticized gutta-percha obturation concept. Based on this concept, the Hygenic Corp. developed a low-temperature injection-molded thermoplasticized gutta-percha delivery system (Ultrafil). Johnson (5) described a technique of carrying thermoplasticized gutta-percha with a metal carrier to the full extent of the prepared canal. Based on this technique, a commercial product that incorporates a central carrier coated with alpha-phase gutta-percha in a prepackaged form, known as Thermafil (Tulsa Dental Products, Tulsa, OK, USA) was introduced. Further studies showed that thermoplasticized gutta-percha was more capable of replicating the intricacies of the root canal system (6,7).

To arrange the gutta-percha as a paste form can be use for obturation, also some solvents of gutta-percha are also used to adapt the apical portion of the master cone to the canal. Chloroform and Xylene are commonly used gutta-percha solvent, but their carcinogenicities were also reported (8). Eucalyptol and halothane are the only known solvents of gutta-percha which are available for clinical use and not considered as potential carcinogens yet (9). Halothane was claimed to be the most promising one because Wourms et al. (10) reported it as effective as chloroform and about more effective as eucalyptol about dissolving gutta-percha in.

Many studies were done about apical sealing property of root canal filling materials and association obturation techniques and many different methods were used to measure leakage such as dye penetration tests, radioactive isotope studies, electro-chemical leakage tests, bacterial penetration tests, scanning electron microscopic analysis, and fluid transport technique (11-16). Among these methods, dye penetration studies are the most common one. However, many studies either revealed non-significant differences or contradictory results. Fluid transport method overcomes some of the disadvantages of previous studies (16).

The purpose of this in vitro study was to compare apical leakages of four root canal obturation techniques; laterally condensed gutta-percha technique, thermoplasticized gutta-percha technique with a carrier (Maillefer-Thermafil, Dentsply, USA), thermoplasticized injectable gutta-percha (Ultrafil, The Hygenic Corp, Akron OH, USA) technique and halothane dipped gutta-percha technique by using a fluid transportation model.

Material and Methods

Sixty one single rooted human premolar teeth (extracted for periodontal reasons) were used. All teeth were free from calcification, internal/external resorptions, fractures, or immature apices. Soft tissue and calculus were removed mechanically from the root surfaces of these teeth. Teeth were stored in deionized water until they are used.

Crowns were removed at the apically 17 mm of roots using an Isomet low-speed saw (Buehler Ltd, Lake Bluff, IL, USA). After gross pulp tissue removal, a K file ISO#15 (MANI, Japan) was introduced into the canal until it could be seen in the apical foramen. Working lengths were established 1 mm short of the apical foramen, and the roots were instrumented using nickel-titanium ProFile® .06 taper ISO series rotary instruments (Tulsa Dental Products, Tulsa, OK, USA). The same operator instrumented all the teeth to the same size. Instrumentation was performed according to the manufacturer’s recommendations. ProFile® instruments were used in crown-down movements with the Tri-Auto hand piece with 350-rpm clockwise rotations. The canals were enlarged to a diameter of 0.5 mm at the apical stop, with patency assured by periodic recapitulation with a size 15 K file. During the instrumentation procedures, the canals were irrigated with 2 mL of 5.25% NaOCl solution. Canals were dried with paper points (DiaDent, Chongju City, Korea). The roots were randomly divided into four experimental groups of 15 roots each (1 root served as a positive control) and prepared as follows;

Table 1. The microleakage values (Mean ± SDs) for experimental groups.

Groups	Technique	N	Lp (µL min^{-1} per cm H_2O)
1	Lateral Condensation	15	1.77 x 10-4 ± 1.649 x 10-4
2	Thermafil	15	1.67 x 10-4 ± 1.259 x 10-4
3	Ultrafil	15	5.16 x 10-4 ± 4.528 x 10-4
4	Halothane Dipped	15	1.02 x 10-4 ± 0.641 x 10-4

Positive control: 113 µL min^{-1} per cm H_2O

Group 1 (Control Group): Roots were obturated by lateral condensation technique. A standard size (ISO#50) gutta-percha master cone (DiaDent, Chongju City, Korea) was fitted to the working length. Freshly mixed AH Plus (De-Trey, Zurich, Switzerland) was introduced into the canal using a lentulo spiral instrument (Dentsply, Maillefer, Ballaigues, Switzerland). Master gutta-percha point was coated with the sealer and placed in the canal to the working length. A size 30 finger spreader (Dentsply, Maillefer, Ballaigues, Switzerland) was then inserted into the canal to a level ~1 mm shorter than the working length. Fine accessory cones coated with sealer were laterally condensed until the entire canal was obturated. Excess gutta-percha was removed with a heated ball burnisher and compacted vertically 1 mm using Machtou's heat-carrier plugger (Dentsply, Maillefer, Ballaigues, Switzerland).

Group 2: #50 size of plastic core Thermafil (Maillefer-Thermafil, Dentsply, Tulsa, OK, USA) obturator was selected by using the Thermafil size verification kit. Cones were placed in the ThermaPrep oven for a maximum of 15 minutes according to the manufacturer's instructions. Root canals were lightly coated with AH Plus using a paper point and the plasticized Thermafil device was inserted to the predetermined level. The shank of each carrier was cut with an inverted cone bur while holding the handle of the obturator at the desired level. Circumferential gutta-percha was condensed vertically.

Group 3: Ultrafil (Hygenic Corp. Akron, OH, USA), a low temperature thermoplasticized injectable gutta-percha system, was used in this group to obturate the root canal according to the manufacturer's instructions. Before obturation, each cannula was preheated in the Ultrafil heater (Hygenic Corp. Akron, OH) for 15 minutes. After placing the sealer with a lentulo spiral instrument, the needle of each cannula was placed into the root canal to a preset level, approximately 5 mm from the apical construction. Gutta-percha was then injected until it extruded coronally. Finally, a plugger was used to pack the gutta-percha vertically.

Group 4: A standard size (ISO#50) master gutta-percha cone was dipped into halothane (Zeneca Abdi İbrahim İlaç San. ve Tic. AŞ. İstanbul, TÜRKİYE) for 5 seconds. The cone was placed into the wet root canal to the working length to obtain an impression of the apical seat. After 30 seconds, the cone was removed from the canal and was allowed to dry for an additional 3 minutes. After placing the AH Plus with a paper point onto whole canal walls, the apical 5 mm of the master cone was coated with sealer and its was precisely reinserted into the canal to the working length using the orientation mark on the root surface. Lateral condensation with fine gutta-percha point was performed until the entire canal was obturated.

The access cavities were then filled with Cavit G (ESPE, Seefeld, Germany) and the teeth were left in saline solution for 1 week at 37ºC. Each tooth was then placed into device designed to measure microleakage by fluid transport as described previously by Wu et al (16).

Quantitative measurement of the sealing properties of the four gutta-percha techniques was described as follows (Figure 1). 25 µL micropipette (Microcaps, Fisher Scientific, Philadelphia, PA, USA), syringes and the plastic tubes at apical sides of the specimens were filled with distilled water. The micropipette was connected to the plastic tube at the outside of the specimen. Water was sucked back with the microsyringe for approximately 2 mm in the other end of the micropipette. By this way, an air bubble was created in the micropipette and adjusted to a suitable position with the syringe. Finally, O_2 from a pressure tank of 3 Psi (0.2 atm) was applied at

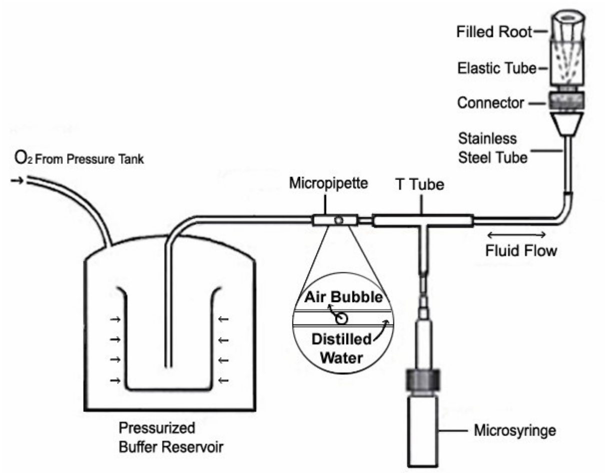

Figure 1. Schematic view of the apparatus used to measure fluid flow along the obturated root canals as a hydraulic conductance.

the apical side and water was forced through the voids along the root canal filling, displacing the air bubble in the micropipette with the water transportation. The volume of the transported fluid was measured by observing the movement of this air bubble. Fluid movements were measured at 2-min intervals for 8 min, which the average of 4 measurements used. The quality of the seal of each specimen was measured at 7th day.

Statistical Analysis: A one-way analysis of variance (ANOVA) analyze was used. The confidence level used was 95% ($p< 0.05$).

Results

The microleakage values (Mean ± SDs) for experimental groups were summarized in Table 1. There was no significant difference among the groups obturated with group 1 (lateral condensation), group 2 (thermoplasticized gutta-percha on a carrier, Thermafil) and Group 4 (halothane dipped gutta-percha techniques ($p> 0.05$). However, with the thermoplasticized injectable gutta-percha (Ultrafil) technique (group 3), there was more leakage when compared to the other groups ($p< 0.05$).

Discussion

Several studies demonstrated that the most common cause of endodontic failure is the incomplete sealing of the root canal space (17). Various obturation techniques and materials have been used for root canal filling. Gutta-percha has been used for obturation since 1867, and many different gutta-percha root canal obturation techniques have been introduced in order to increase the quality of sealing (18).

Lateral condensation of gutta-percha is widely used method of the root canal obturating system (19). It is a relatively simple and versatile technique that does not need expensive equipment (20). Although some authors reported that lateral condensation could not approach a homogeneous mass of gutta-percha and it was not closely adapted to the root canal walls, (1) lateral condensation is often used as a control for evaluating the sealing ability of new obturation techniques. Therefore, this technique was used as a control in this study.

A standard root canal preparation technique is required to compare these kinds of studies. The canal preparation technique may have an effect on the results (21). To reduce variability, all specimens were prepared and filled by the same operator, and the techniques were practiced extensively beforehand.

In an in vitro study by Dummer et al. (22) it is claimed that, from the standpoint of microleakage, Thermafil obturation technique can be an acceptable alternative technique when compared to the lateral condensation technique. They have compared lateral condensation of gutta-percha technique and Thermafil obturating technique and have not reported any significant difference in dye penetration. This result is in agreement with the present study. Also Beatty et al. (23) and Gencoglu et al. (24) have found that the use of the Thermafil technique resulted in less leakage than the lateral condensation technique. However, in another dye penetration study, Gatewood et al. (25) and Hata et al., (26) reported that lateral condensation technique could achieve better results when compared to the Thermafil technique.

In this study, although halothane dipped technique demonstrated less leakage than the other techniques, there is no statistically significant difference when compared to the lateral condensation or Thermafil techniques. These results are in agreement with the study by Smith and Montgomery (27) and but in contrast with the work of Dickson et al. (28) In their studies, dye leakage of the gutta-percha of the halothane-dipped groups advanced more significantly than the lateral condensation groups.

In the present study, Ultrafil, (thermoplasticized gutta-percha technique) showed unacceptable leakage. When the results were statistically analyzed, significantly more leakage was detected than the other tested groups. This finding is in contrast with the previous studies (24,29). Application and clinical use of Ultrafil technique requires sensitivity. The waiting period, to carry heated gutta-percha, control of the gutta-percha to prevent apical exposure all makes this technique difficult. It requires long term clinical experience. We believe that a considerable experience with Ultrafil technique can cause higher clinical success.

As a conclusion, according to the results of this in vitro study, we recommend Thermafil technique, halothane dipped technique and traditional lateral condensation technique for obturation of the root canals. Further long term clinical studies are still needed for these methods.

REFERENCES

1. Nguyen TN: Obturation of the root canal system. In: Cohen S, Burns RC, eds. Pathways of the Pulp. St. Louis, CV Mosby, 1994, s.219.
2. Schilder H: Filling root canals in three dimensions. Dent Clin North Am 11: 723, 1967
3. Sundqvist G, Figdor D: Endodontic treatment of apical periodontitis. In: Ørstavik D, Pitt Ford TR, eds. Essential Endodontology. Oxford UK, Blackwell Science, 1998, s.242.
4. Yee FS, Marlin J, Krakow AA, Gron P: Three-dimensional obturation of the root canal using injection-molded, thermoplasticized dental gutta-percha. J Endod 3: 168, 1977
5. Johnson WB: A new gutta-percha technique. J Endod 4: 184, 1978
6. Budd CS, Weller RN, Kulild JC: A comparison of thermoplasticized injectable gutta-percha obturation techniques. J Endod 17: 260, 1991
7. Gutmann JL, Saunders WP, Saunders EM, Nguyen L: An assessment of the plastic Thermafil obturation technique. Part 1. Radiographic evaluation of adaptation and placement. Int Endod J 26: 173, 1993
8. United States Food and Drug Administration: Chloroform, use as an ingredient (active or inactive) in drug products. In: Federal Register No: 26845. Washington DC, Government Printing Office, 1976
9. US Department of Health and Human Services: Public Health Service fourth annual report on carcinogens, PB 85-134663, 1985
10. Wourms DJ, Campbell AD, Hicks ML, Pelleu GB Jr: Alternative solvents to chloroform for gutta-percha removal. J Endod 16: 224, 1990
11. Spångberg LS, Acierno TG, Yongbum Cha B: Influence of entrapped air on the accuracy of leakage studies using dye penetration methods. J Endod 15: 548, 1989
12. Benner MD, Peters DD, Grower M, Bernier WE: Evaluation of a new thermoplastic gutta-percha obturation technique using 45Ca. J Endod 7: 500, 1981
13. Osins BA, Carter JM, Shih-Levine M: Microleakage of four root canal sealer cements as determined by an electrochemical technique. Oral Surg Oral Med Oral Pathol 56: 80, 1983
14. Delivanis PD, Mattison GD, Mendel RW: The survivability of F43 strain of Streptococcus sanguis in root canals filled with gutta-percha and Procosol cement. J Endod 9: 407, 1983
15. Tanzilli JP, Raphael D, Moodnik RM: A comparison of the marginal adaptation of retrograde techniques: A scanning electron microscopic study. Oral Surg Oral Med Oral Pathol 50: 74, 1980
16. Wu MK, De Gee AJ, Wesselink PR: Fluid transport and dye penetration along root canal root canal fillings. Int Endod J 27: 233, 1994
17. Ray HA, Trope M: Periapical status of endodontically treated teeth in relation to the technical quality of root filling and coronal restoration. Int Endod J 28: 12, 1995
18. Wennberg A, Ørstavik D: Evaluation of alternatives to chloroform in endodontic practice. Endod Dent Traumatol 5: 234, 1989
19. Walton RE: Torabinejad M: Principles and Practice of Endodontics. 1st ed. Philadelphia WB Saunders, 1989, s.236.
20. Jenkins SM, Hayes SJ, Dummer PM: A study of endodontic treatment carried out in dental practice within the UK. Int Endod J 34: 16, 2001
21. Gilhooly RM, Hayes SJ, Bryant ST, Dummer PM: Comparison of lateral condensation and thermomechanically compacted warm alpha-phase gutta-percha with a single cone for obturating curved root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 91: 89, 2001
22. Dummer PM, Kelly T, Meghji A, Sheikh I, Vanitchai JT: An in vitro study of the quality of root fillings in teeth obturated by lateral condensation of gutta-percha or Thermafil obturator. Int Endod J 26: 99, 1993

23. Beatty RG, Baker PS, Haddix J, Hart F: The efficacy of four root canal obturation techniques in preventing apical dye penetration. J Am Dent Assoc 119: 633, 1989
24. Gençoglu N, Garip Y, Bas M, Samani S: Comparison of different gutta-percha root filling techniques: Thermafil, Quick-fill, System B, and lateral condensation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 93: 333, 2002
25. Gatewood RS, Parsell DE, Rushing CC: Cross-sectional assessment of apical dye penetration following clinical simulation of various endodontic techniques. Gen Dent 52: 342, 2004
26. Hata G, Kawazoe S, Toda T, Weine FS: Sealing ability of Thermafil with and without sealer. J Endod 18: 322, 1992
27. Smith JJ, Montgomery S: A comparison of apical seal: chloroform versus halothane-dipped gutta-percha cones. J Endod 18: 156, 1992
28. Dickson SS, Peters DD: Leakage evaluation with and without vacuum of two gutta-percha fill techniques. J Endod 19: 398, 1993
29. Dalat DM, Spångberg LS: Comparison of apical leakage in root canals obturated with various gutta percha techniques using a dye vacuum tracing method. J Endod 20: 315, 1994

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Correspondence: Necdet ADANIR, MD
Department of Endodontics,
Faculty of Dentistry,
Süleyman Demirel University,
Campus, 32060, ISPARTA
necdet@excite.com

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