J Istanbul Univ Fac Dent 2017;51(2):37-42.
http://dx.doi.org/10.17096/jiufd.95769 ORIGINAL RESEARCH

# IN VITRO COMPARISON OF GUTTA-PERCHA-FILLED AREA PERCENTAGES IN ROOT CANALS INSTRUMENTED AND OBTURATED WITH DIFFERENT TECHNIQUES*

## Farklı Sistemlerle Şekillendirilen ve Doldurulan Kök Kanallarındaki Güta-Perka Kaplı Alan Yüzdelerinin in vitro Olarak Karşılaştırılması

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### ABSTRACT

**Purpose:** To evaluate the efficacy of different obturation techniques in root canals instrumented either by hand or rotary instruments with regard to the percentage of gutta-percha-filled area (PGFA).

**Materials and Methods:** One hundred and sixty extracted mandibular premolars with single, straight root canals were studied. Root canals were prepared to an apical size of 30 by hand with a modified crown-down technique or the ProTaper and HEROShaper systems. Teeth were divided into eight groups (n=20) according to the following instrumentation and obturation techniques: G1: Hand files+lateral condensation (LC), G2: Hand files+Thermafil, G3: ProTaper+LC, G4: ProTaper+single-cone, G5: ProTaper+ProTaper-Obturator, G6: HEROShaper+LC, G7: HEROShaper+single-cone, G8: HEROShaper+HEROfill. Horizontal sections were cut at 1, 3, 5, 7, 9, 11 and 13 mm from the apical foramen. A total of 1120 sections obtained were digitally photographed under a stereomicroscope set at 48X magnification. The cross-sectional area of the canal and the gutta-percha was measured by digital image analysis and the PGFA was calculated for each section.

**Results:** The mean of the PGFA in Thermafil (G2), ProTaper-Obturator (G5) and HEROfill (G8) groups was significantly higher than the other groups. In G3 and G4, PGFA showed no significant difference in the apical segments whereas PGFA was significantly higher at the middle and coronal segments in G3. In G6 and G7, PGFA showed no significant difference in the apical and middle segments whereas PGFA was significantly higher at the coronal segments in G6.

**Conclusion:** The carrier-based gutta-percha obturation systems revealed significantly higher PGFA in comparison to single-cone and lateral condensation techniques.

**Keywords:** NiTi rotary systems; carrier-based obturation systems; single-cone obturation, gutta-percha-filled area; root canal obturation

### ÖZ

**Amaç:** Bu çalışmanın amacı, el aletleri ve farklı nikel-titanyum döner alet sistemleriyle şekillendirilen kanallarda farklı kanal doldurma tekniklerinin etkinliklerinin güta-perka kaplı alan yüzdeleri (GKAY) açısından karşılaştırılmasıdır.

**Gereç ve Yöntem:** Çalışmada 160 adet çekilmiş, düz ve tek kanallı alt küçük azı dişi kullanılmıştır. 20'şerli 8 deney grubunda şekillendirme ve doldurma işlemleri şu şekilde tamamlanmıştır: G1: El aletleri+lateral kondensasyon (LK), G2: El aletleri+Thermafil, G3: ProTaper+LK, G4: ProTaper+tek kon, G5: ProTaper+ProTaper Obturator, G6: HEROShaper+LK, G7: HEROShaper+tek kon, G8: HEROShaper+HEROfill. Her kök kanalının 7 bölgesinden (apikalden itibaren 1, 3, 5, 7, 9, 11 ve 13 mm) alınan toplam 1120 yatay kesit, 48X büyütmede fotoğraflanmış ve Adobe Photoshop 7.0 programında alan ölçümleri yapılmıştır. Veriler istatistiksel olarak değerlendirilmiştir.

**Bulgular:** Thermafil (G2), ProTaper Obturator (G5) ve HEROfill (G8) gruplarında GKAY ortalamaları diğer gruplara göre istatistiksel olarak anlamlı derecede yüksektir. G3 ve G4'te GKAY değerleri arasında apikal bölgede belirgin fark yokken, orta ve kuronal bölgede G3'te belirgin yüksektir. G6 ve G7'de apikal ve orta bölgelerde GKAY arasında anlamlı fark yokken, kuronal bölgede G6 grubunda istatistiksel olarak anlamlı yüksek bulunmuştur.

**Sonuç:** Termoplastik kor sistemleri kullanılarak gerçekleştirilen kök kanalı dolgularında, ölçülen GKAY değerleri tek kon ve lateral kondensasyon tekniklerine göre belirgin olarak yüksektir.

**Anahtar kelimeler:** NiTi döner alet sistemleri; termoplastik kor sistemleri; tek kon; güta- perka kaplı alan yüzdesi; kök kanalı dolgusu

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## Introduction

The use of nickel-titanium (NiTi) rotary systems in instrumenting root canals has brought a new progress in endodontic practice. Their efficiency in preparing root canals has been reported in several studies (1, 2). Many techniques have been developed to obturate the root canals but lateral condensation of gutta-percha has been the widely used technique. Recently, the manufacturers have introduced their individual tapered gutta-percha master cones to match the taper and apical sizes of the canals prepared with the respective NiTi rotary system claiming that the matched taper points can fill tapered canals effectively since they correspond to canal shapes created by instruments of similar taper. Manufacturers also recommend obturation of the root canals prepared with NiTi rotary systems by using their respective thermoplasticized gutta-percha coated carrier systems. The carrier-based systems consist of a plastic core coated with α-phase gutta-percha and a heating device that controls the temperature. Obturators are designed to correspond to the ISO standard file sizes and variable tapered NiTi rotary files (3). It was stated that these techniques are capable of producing a homogenous mass in the root canal with a better gutta-percha-to-sealer ratio than that achieved with cold lateral condensation (4). It was also reported that there was no difference in healing rates of cases treated with carrier-based systems and lateral condensation of gutta-percha (5).The American Association of Endodontists' Guide to Clinical Endodontics states that root canal sealers are used in conjunction with a biologically acceptable semi-solid or solid obturating material to establish an adequate seal of the root canal system (6). Some sealers shrink upon setting and some are soluble over time and their dissolution may cause an increase in leakage along the root canal filling (7, 8). Therefore, the optimal outcome in canal filling is to maximize the volume of the core material and minimize the amount of the sealer (7-9). Many studies reported that the percentage of gutta-percha filled area (PGFA) and the quality of the filling technique are closely related (9-11). Previous studies reported comparable PGFA values in the horizontal root sections when comparing single-cone obturation technique with the lateral condensation technique or thermoplasticized gutta-percha methods (12-15). However, no attempts have been made to compare different preparation systems used with their respective matched-taper single-cone or carrier-based obturation system. The aim of this study was to evaluate the efficiency of different obturation techniques in root canals instrumented either by hand or rotary instruments by assessing the PGFA in the horizontal root sections.

## Materials and Methods

### *Sample characteristics*

One hundred and sixty intact mature human premolars with single, straight root canals which had been extracted for reasons unrelated to the current study were obtained from Department of Oral and MaxilloFacial Surgery, Istanbul University.

### *Specimen preparation*

Access cavities were prepared, a #10 K-file was inserted into the root canal until it was just visible at the apical foramen, and working length was established by subtracting 1 mm from this length. Root canals were prepared to an apical size of 30 by hand files in a modified crown-down technique (16), using ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) or HEROShaper (Micro-Mega, Besançon, France) rotary systems according to the manufacturers' instructions. Root canals were obturated with the conventional lateral condensation, single-cone (#30 ProTaper Universal gutta-percha; Dentsply Maillefer and #30 MM-GP Points 4%; Micro-Mega) or carrier-based obturation techniques (Thermafil Obturator #30; Dentsply, Tulsa, USA and ProTaper Obturator F3; Dentsply and HEROfill Obturator #30; Micro-Mega). Teeth were randomly divided into the following eight groups (n=20) according to the instrumentation and obturation techniques used: G1: Hand files, lateral condensation; G2: Hand files, Thermafil; G3: ProTaper, lateral condensation; G4: ProTaper, single-cone (ProTaper Universal); G5: ProTaper, ProTaper-Obturator; G6: HEROShaper, lateral condensation; G7: HEROShaper, single-cone (MM-GP points); G8: HEROShaper, HEROfill. Root canals were irrigated with 2 ml of 2.5% NaOCl between each file during instrumentation and 10 ml of 17% EDTA followed by 10 ml of 5.25% NaOCl and 10 ml of distilled water were used as final irrigation. AH26 silver-free root canal sealer (Dentsply DeTrey, Konstanz, Germany) was used for all the obturation techniques. A small amount of carbon black powder that does not alter the consistency of the sealer (17) was added to the mixed paste to make it distinguishable in the root sections. Using a 0.6 ml syringe, a standard volume of 0.05 ml of sealer was delivered into the root canal. A #2 lentulo

spiral was used with a low-speed handpiece at a speed of 1500 rpm to the working length with an up-and-down motion within the canal six times.Following obturation, the teeth were stored in an incubator at 37°C and 100% humidity for 7 days to allow complete setting of the sealer. The specimens were then embedded in epoxy resin. For each specimen, horizontal sections were cut at 1, 3, 5, 7, 9, 11 and 13 mm from the apical foramen, using a low speed saw (Isomet 1000; Buehler, IL, USA) at a low speed setting and continuous water cooling to prevent frictional heat and smearing of the gutta-percha. The saw actually made a cut of 0.3 mm thick. The first cut was made at 1 mm occlusal to the anatomical apex (i.e. the apical end point of the working length), and the next cuts were made at 1.7 mm occlusal to the previous cuts. The coronal surface of each section was digitally photographed at 48X magnification under a stereomicroscope (Leica MZ75, Leica Imaging Systems Ltd, Cambridge, UK).

*Measurement protocols*

Images were transferred to the image-analysis program (Leica QWin, Leica Imaging Systems Ltd., Cambridge, UK). The photographs taken from a total of 1120 sections were recorded as tagged image file format (TIFF) images (Fig. 1). The areas of the gutta-percha, sealer and voids were measured by counting the pixels using Adobe Photoshop 7.0 (Adobe System INC., San Jose, CA, USA). The area of the plastic core material was included in the gutta-percha area for the thermoplasticized techniques. The total root canal area was accepted as the sum of these values. Then the PGFA was calculated for each section.

*Statistical analysis*

The data was analyzed using NCSS 2007&PASS 2008 Statistical Software (NCSS, LLC, Kaysville, Utah, USA). The standard descriptive methods such as the mean, standard deviation were applied to determine the characteristics of the sample. Because the distribution of the data met the requirements for normality and homogeneity of variances assumptions, one-way analysis of variance (ANOVA), post hoc Tukey's Honestly Significant Difference (Tukey HSD) tests were used to compare the groups. Two independent variables were compared with Student's t-test. The confidence interval was set to 95% and $p<0.05$ was considered statistically significant.

**Results**

The mean of the PGFAs in each group and statistical analysis of the data are presented in Table 1. The groups were then compared using Tukey HSD and the means of the PGFAs in all of the thermoplasticized gutta-percha coated carrier-based groups (G2- Thermafil, G5- ProTaper Obturator and G8- HEROfill) were found to be significantly higher than those of all other groups. The horizontal sections cut at 1, 3 and 5 mm were referred as apical, at 7 and 9 mm as middle and at 11 and 13 mm as coronal segments while comparing the groups (Figure 1).

***Table 1.*** *The means and standard deviations (SD) of the percentages of gutta-percha-filled area (PGFA) values obtained from all of the 7 sections in each group. G1: Hand-files+lateral condensation (LC), G2: Hand-files+Thermafil, G3: ProTaper+LC, G4: ProTaper+single-cone, G5: ProTaper+ProTaper-Obturator, G6: HEROShaper+LC, G7: HEROShaper+single-cone, G8:HEROShaper+HEROfill).*

| Groups | PGFA (%) mean ± SD |
|---|---|
| **G1** | $78.84\pm6.53^{a}$ |
| **G2** | $94.34\pm4.60^{b}$ |
| **G3** | $76.56\pm7.63^{ac}$ |
| **G4** | $67.39\pm14.20^{d}$ |
| **G5** | $91.47\pm4.21^{b}$ |
| **G6** | $74.93\pm7.50^{acd}$ |
| **G7** | $69.85\pm10.52^{cd}$ |
| **G8** | $88.03\pm6.64^{b}$ |

*Different superscript letters represent statistical difference (Tukey HSD test).*

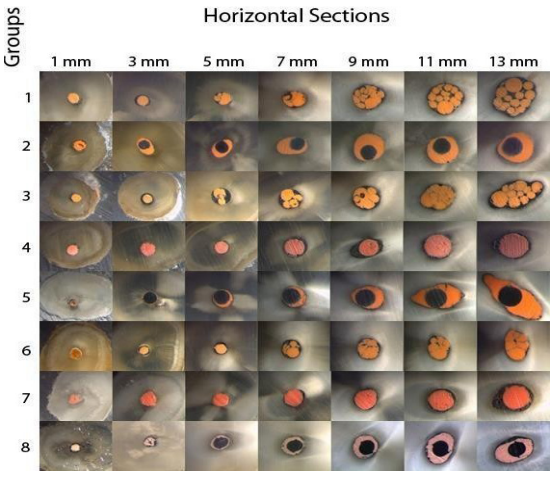


***Figure 1.*** *Representative photographs taken from seven sections of a tooth sample from each group. Groups (G) are as follows: G1:Hand-files+lateral condensation (LC), G2:Hand-files+Thermafil,G3:ProTaper+LC, G4:ProTaper+single-cone, G5:ProTaper+ProTaper-Obturator,G6:HEROShaper+LC, G7:HEROShaper+single-cone, G8:HEROShaper+HEROfill.*

When the groups instrumented with hand files and obturated with lateral condensation (G1) or Thermafil technique (G2) were compared with each other by using Student's t-test, G2 showed significantly higher PGFAs than G1 at all segments ($p<0.01$). When the groups instrumented with the ProTaper system and obturated with lateral condensation (G3), ProTaper Universal single-cone (G4) or ProTaper-Obturator technique (G5) were compared with each other by using one-way ANOVA, the groups showed statistically significant differences at all segments ($p<0.01$). Comparison of the groups at all segments by using Tukey HSD demonstrated that at the apical segments, PGFAs in G5 were significantly higher than those of G3 and G4. However, no significant difference was found between G3 and G4. At the middle and coronal segments, PGFAs in G5 were significantly higher than those of G3 and G4 whereas G3 showed significantly higher PGFAs than G4. When the groups instrumented with the HERO Shaper system and obturated with lateral condensation (G6), MM-GP points single-cone (G7) or HEROfill technique (G8) were compared with each other by using one-way ANOVA, the groups showed statistically significant differences at all segments ($p<0.01$). Comparison of the groups at all segments by using Tukey HSD demonstrated that at the apical segments, PGFAs in G6 were significantly lower than that of G8. However, no significant difference was found between G7 and G6 as well as G7 and G8. At the middle segments, PGFAs in G8 were significantly higher than those of G6 and G7. However, no significant difference was found between G6 and G7. At the coronal segments, PGFAs in G7 were significantly lower than those of G6 and G8. However, no significant difference was found between G6 and G8. The carrier-based gutta-percha systems showed statistically higher PGFAs at horizontal sections of the apical, middle and coronal root segments compared to the other groups. In the comparison of the groups instrumented with hand files, Thermafil group showed significantly higher PGFAs than those of the lateral condensation group at all segments. In the comparison of the groups instrumented with the ProTaper system, the ProTaper Obturator group showed significantly higher PGFAs than those of the other two groups at all segments. Whereas the difference between single-cone and lateral condensation groups was not significant at the apical segment, lateral condensation group showed significantly higher PGFAs than the single-cone group at the middle and coronal segments. In comparison of the groups instrumented with the HERO Shaper system, the HEROfill group showed significantly higher PGFAs than the lateral condensation group at the apical and middle segments, whereas the difference at all coronal segments was not significant between these two groups. There was no significant difference between the single- cone and lateral condensation groups at the apical and middle segments, whereas the lateral condensation group showed significantly higher PGFAs at the coronal segment.

**Discussion**

The method of cross-sectional analysis has been widely used to evaluate the efficiency of obturation techniques by expressing the percentage of gutta-percha, sealer and voids in root canal sections (4, 9, 11, 12, 18-25). Gutta-percha is known as dimensionally stable (17) whereas most of the sealers present shrinkage on setting (26). Thus PGFA in the horizontal root sections has been used to evaluate the quality of the obturation in the present study. In the present study, Thermafil technique (G2) showed significantly higher PGFAs than the lateral condensation technique (G1) at all segments of the root canals instrumented with hand files. This finding corroborates with the findings of Samadi *et al.* (23) and De-Deus *et al.* (9, 20) who reported the same results for Thermafil group in comparison with the lateral condensation in the cross-sectional root canal areas instrumented with hand files. Gülşahi *et al.* (22) concluded that the combined use of ProFile + Thermafil Obturator and System GT + GT Obturator resulted in significantly less sealer component in the cross- sectional areas at apical, mid-root and coronal thirds, compared with that achieved with both NiTi preparation systems followed by cold lateral compaction. The present study aimed to find out the efficient instrumentation-obturation technique combination and gave similar results to those of Gülşahi *et al*. (22); that is combined use of the ProTaper rotary system with ProTaper Obturator (G5) and the HERO Shaper rotary system with HEROfill (G8) produced significantly higher PGFAs than the lateral condensation groups instrumented with either of these rotary systems (G3 and G6). Gençoğlu (4) reported that in horizontal sections at 1, 2, 3 and 4 mm, the core techniques (Thermafil, JS Quick-Fill and Soft Core) produced higher gutta-percha content than the Microseal, System B and lateral condensation techniques, and of the core techniques, Thermafil produced the highest ratio of gutta-percha

to sealer though the difference was not significant. The findings of the present study corroborate with the results of the previous study such that at the apical segment no significant difference was found among the carrier-based gutta-percha systems (Thermafil, ProTaper Obturator and HEROfill) and Thermafil group showed the highest PGFA though the difference was not significant. Schafer *et al*. (25) also compared the different obturation techniques in terms of the PGFA and the percentages of sealer filled area and voids in straight root canals prepared with different instruments and concluded that regardless of the instrument used for canal preparation the carrier-based gutta-percha techniques (GuttaCore and GuttaFusion) produced very homogenous obturations with high PGFA. Their findings corroborate with the results of the present study which showed that the carrier-based gutta-percha systems (Thermafil, ProTaper Obturator and HEROfill) revealed significantly higher PGFAs among all groups. Gordon *et al.* (12) compared the area occupied by gutta-percha, sealer or void in simulated curved canals and mesio-buccal canals of extracted maxillary first molars prepared with 6% ProFile and filled with a single 6% gutta-percha point or lateral condensation of multiple 2% gutta-percha points and concluded that the 6% taper single-cone technique was comparable with lateral condensation in the amount of gutta-percha occupying a canal prepared to 6%. However, our results showed that at the coronal segments the PGFAs for the lateral condensation groups (G3 and G6) were significantly higher than those of the single- cone groups (G4 and G7) whereas at the apical segments there was no significant difference among the groups. The use of resin blocks and mesio-buccal canals of maxillary first molars may have an influence on the contradictory results due to the narrow configurations of these canals. Various studies have reported that the anatomical variations, the presence of oval or round canal shapes may affect the outcome of the obturation technique (11, 21, 27, 28). The teeth included in the present study were randomly selected and not classified as oval or round canals to simulate the clinical conditions.

## Conclusion

Within the limitations of this ex-vivo study, the carrier-based obturation systems seem be an effective modality in root canal filling of teeth with straight canals.

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None declared.

**Conflict of Interest**
None declared.

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