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ORIGINAL ARTICLE

# Percentage of Gutta-percha filled area in canals shaped with Nickel-Titanium instruments and obturated with GuttaCore and Conform Fit gutta-percha cones

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## ABSTRACT

***Aim:*** *The purpose of this study is to compare continuous wave with conform fit gutta-percha point and the core-carrier system with GuttaCore assessing the percentage of gutta-percha filled areas (PGFA), sealer filled areas (PSFA) and voids (PVA) in extracted teeth.*
***Methodology:*** *Seventy-five extracted single rooted premolars were assigned to 5 groups, groups A and C were shaped with WaveOne Gold medium, groups B and D with ProTaper Next X3, and group E with manual instruments #35 K-file. Obturations were managed with GuttaCore in groups A and C; with Conform fit gutta-percha points in groups B and D; and with ISO-sized 35 gutta-percha master cones and cold lateral compaction technique in group E. The teeth were sectioned at 2, 4, 6, and 8 mm from the apex and for every section the percentages of gutta-percha and sealer filled, and void areas with respect to the total area were calculated. Data obtained were analysed for each variable at each level by using a one-way ANOVA with group as dependent variable (α=0.05). Multiple comparisons between the five experimental groups were conducted by using the Student's t-test with Šidák alpha correction.*
***Results:*** *At all levels group E produced significantly less PGFA and higher PSFA and PVA than all the other experimental groups. At 2 mm from the apex, group A showed significantly higher PGFA than group C and a significantly lower PSFA than C and D. At 4 mm from the apex groups A and B produced significantly better results in terms of PGFA than groups C and D. the PSFA and PVA were significantly lower in group D with respect to groups A and B. PVA were statistically significant lower in group C than in group B. At 8 mm from the apex group A showed significantly higher PGFA than groups B and D, a significantly lower PSFA and PVA than group B.*
***Conclusions:*** *Independently of the instrument used for preparation (WaveOne gold versus ProTaper Next) Conform Fit point and GuttaCore produced very homogeneous obturations with high PGFA. The association of WaveOne Gold file system shaping and the GuttaCore obturation technique produced better results in terms of PGFA, PSFA and PVA than all the other techniques especially in the apical portion of the root canals. Manual instrumentation and the cold lateral obturation technique yield poor quality root canal obturations.*

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**KEYWORDS** *Continuous wave obturation, core carrier system, guttacore, PGFA, vertical warm obturation*

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## Introduction

Preventing bacteria from entering the endodontic system is a fundamental biological principle for achieving a successful treatment (1). A recent systematic review and meta-analysis concluded that both adequate root canal treatment and restoration are fundamental for saving functional teeth (1). These results strengthen findings of previous reviews.

A satisfactory endodontic obturation without voids is one of four factors with a significantly positive effect on the outcome of primary root canal treatment (2).

Research is aiming at matching engine-driven nickel-titanium (NiTi) instruments with an appropriate obturation technique that will seal all ports of entry to prevent bacterial contamination. A 3-dimensional (3D) adaptation of the filling material to the root canal space could be accomplished with the core-carrier system or single-cone gutta-percha technique with the same taper and diameter of the last instrument used (3-5).

Both methods are based on the use of thermoplasticized gutta-percha. The dimensional stability of the obturation is directly dependent on filling the canal with gutta-percha using as little sealer as possible and leaving no void areas (6-8). The quality of the obturation can then be evaluated in terms of the percentage of gutta-percha filled areas (PGFA), sealer filled areas (PSFA), and voids (PVA) in filled straight-root canals using digital images (9-12).

In the single-cone gutta-percha technique, the adaptation to the endodontic space was achieved with the warm vertical compaction or continuous wave compaction technique. In 2013 Schäfer et al. found that the variable taper of root canal instrumentation negatively influenced obturation quality with single-cone gutta-percha (4).

Recently, new Conform-Fit gutta-percha points (Dentsply, Sirona, Canada), that closely matched the variable taper of relative Ni-Ti instruments (ProTaper NEXT and WaveOne Gold), were introduced. Previous studies stressed the importance of correspondence between the diameters and tapers of the files and the gutta-percha cones (13, 14).

The manufacturer described the Conform Fit Gutta-Percha point as a micronized gutta-percha formula that permits thermoplastic adaptation at low temperatures (105-180°) minimizing any negative effect on the periodontal ligament (15).

Until recently core-carrier were either metal or plastic (Thermafil thecnique) now, the core can be made of cross-linked gutta-percha. However, the cores are always coated alpha-phase gutta-percha.

The most popular core carrier systems with cross-linked gutta-percha are Gutta-Core (Dentsply Maillefer, Ballaigues, Switzerland) and GuttaFusion (VDW, Munich, Germany). These systems seem to guarantee a high quality of obturation with respect to lateral and Single-Cone techniques even with the use of different instruments with varied and constant tapers (9).

The purpose of the study was to compare the quality of obturation, in terms of percentage of gutta-percha filled area (PGFA) sealer (PSFA) and voids (PVA), in straight root canals instrumented with two varied taper NiTi instruments (Wave One Gold and ProTaper NEXT) and filled with single-cone gutta-percha (Conform Fit point) or the Gutta-Core carrier system.

The tested null hypothesis was that there is no difference in the quality of obturations between two techniques.

## Materials and Methods

Seventy-five straight root canal (curvature <5°) mandibular premolars, extracted for periodontal disease, were selected for this study. The study was approved by the ethics committee of the Tuscany Region, University of Florence, Italy N17877_BIO. In order to prevent bacterial growth, the teeth were stored at 4 °C until use, in formalin solution. The remaining were then examined with stereomicroscope under X20 magnification; those with root canal cracks were also excluded. The coronal access was realized in all root canals, apical patency was checked and working length measured with a size 10 k-file (Dentsply Maillefer, Ballaigues, Switzerland).

The distance between the cementoenamel junction and the apex was recorded in order to assign the canals to five similar groups (n=15 teeth for group).
After placing the teeth in an endodontic simulator (Protrain; Simit Dental, Mantova, Italy), the electric motor with a 16:1 reduction hand-piece (X-Smart Plus; Dentsply Maillefer, CH-1338 Ballaigues, Switzerland) was set for each file with torque and rotational speed as suggested by manufacturer. The glide path was performed using Wave One Gold Glider in groups A and C and with ProGlider in groups B and D, until working length was reached. In group E manual instrumentation with stainless steel K-File (Dentsply, Maillefer) size 10-35 were used.
In the experimental groups shaping was accomplished using two different NiTi energy driven instruments: in groups A and C Wave One Gold medium (WOGM) (Dentsply, Maillefer); in groups B and D ProTaper Next X3 (PTNX3, Dentsply, Maillefer) until the working length was reached.
After using each instrument, the root canals were irrigated with 5% NaOCl and 17% EDTA using a 30-gauge monojet irrigation needle for a total of 12 ml and 9 ml, respectively; the final rinse was done using 3 ml of saline solution for 1 minute. All the roots were dried with the paper point corresponding to the last instruments used.
Groups A and B were obturated by using the core-carrier system: GuttaCore (GC) obturator (Dentsply Sirona Ballaigues, Switzerland), matching the WOGM and PTNX3 respectively, were heated in a ThermaPrep 2 oven (Dentsply Sirona), on heat setting 35-40 °C. Groups C and D were obturated by using the continuous wave technique: Conform Fit (CF) gutta-percha cone (Dentsply Sirona), matching WOGM and PTNX3 respectively, using the System B (EIE Analytic Technology, Orange, CA); backfilling was accomplished using an Obutra II syringe (Obtura II, Obtura Corporation, Fenton, MO, USA). Finally, group E was obturated with the cold lateral compaction technique using ISO-sized 35 gutta-percha master cones.
In all the samples pulp-canal sealer EWT (Kerr, Salerno, Italy) was used as endodontic sealer. Teeth were stored for 14 days at 37 °C and 100% humidity to allow the sealer to set completely.
The teeth were embedded in resin blocks (Technovit; Heraeus-Kulzer, Wehrheim, Germany) and sectioned horizontally, with a 0.1 mm low-speed saw (Leitz, Wetzlar, Germany) under permanent water-cooling at 2, 4, 6, and 8 mm from the apex. All slices were observed from a coronal to apical direction under a digital stereomicroscope (SMZ-10 Nikon Corporation, Tokyo. Japan) at X40 magnification and digital pictures were taken of each section. The total area of each canal segment and the areas of gutta-percha, sealer, and voids were measured in pixels using ImageJ Software (National Institutes of Health, public domain) for all sections. The areas of gutta-percha, sealer, and void areas, PGFA, PSFA, and PVA respectively, were converted to percentages with respect to the total area.
These sections were analyzed by an examiner blinded to all the experimental groups and sections.

*Statistical Analysis*

The sample size was determined considering the comparison of main interest (i.e. PGA at first level, experimental group A vs. all the other experimental groups). Assuming that the most similar percentages of PGA were observed in the experimental groups A and B (about 94% and 90%, respectively) and considering a common SD of 3 and an alpha level of 0.0127 (i.e. Šidák correction [i.e. $1-(1-\alpha)^{1/m}$] applied to the four contrast of main interest), a sample size of 15 teeth for each experimental group is sufficient to guarantee study power of at least 80%.
Statistical analyses of PGFA, PSFA and PVA were performed for each level (i.e. 2, 4, 6, and 8 mm), using the one-way ANOVA with group as dependent variable. Multiple comparisons between the five experimental groups for each variable at each level were also performed by using t-Test. The overall study statistical significance level was set at $\alpha=0.05$ for each variable within

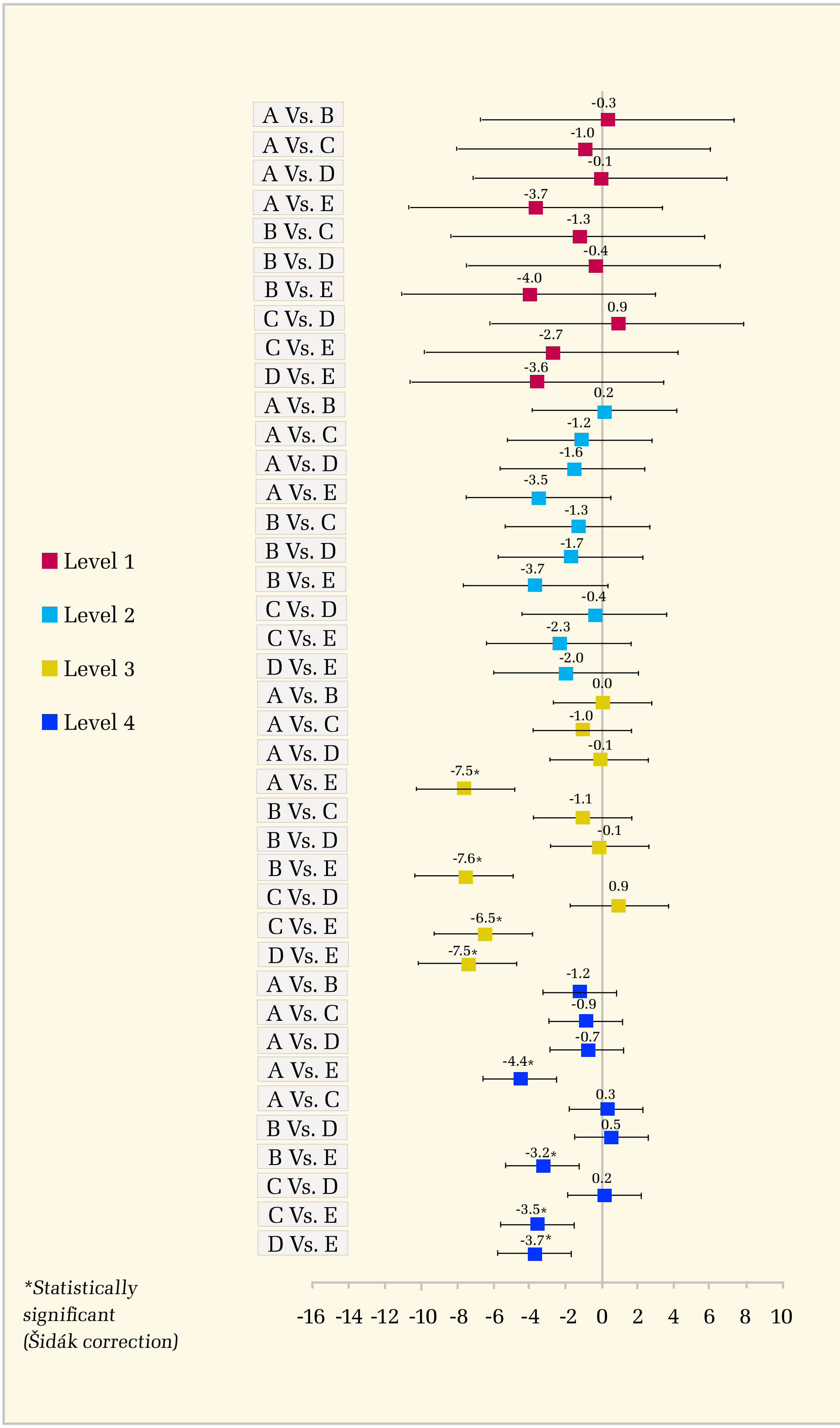


**Figure 1**
PGFA Contrasts by level.

**Figure 2**
PSFA Contrasts by level.

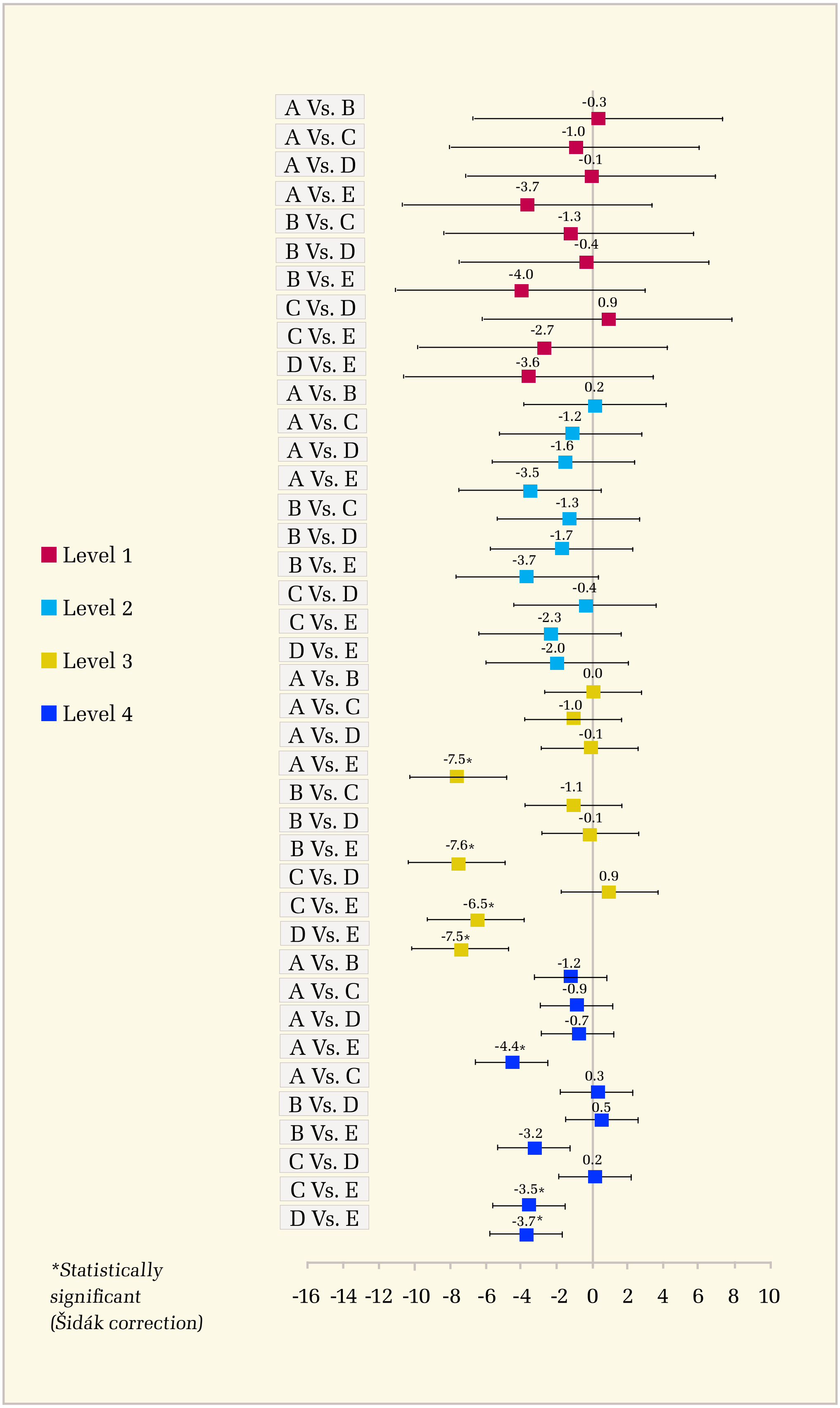

**Figure 3**
PVA Contrasts by level.

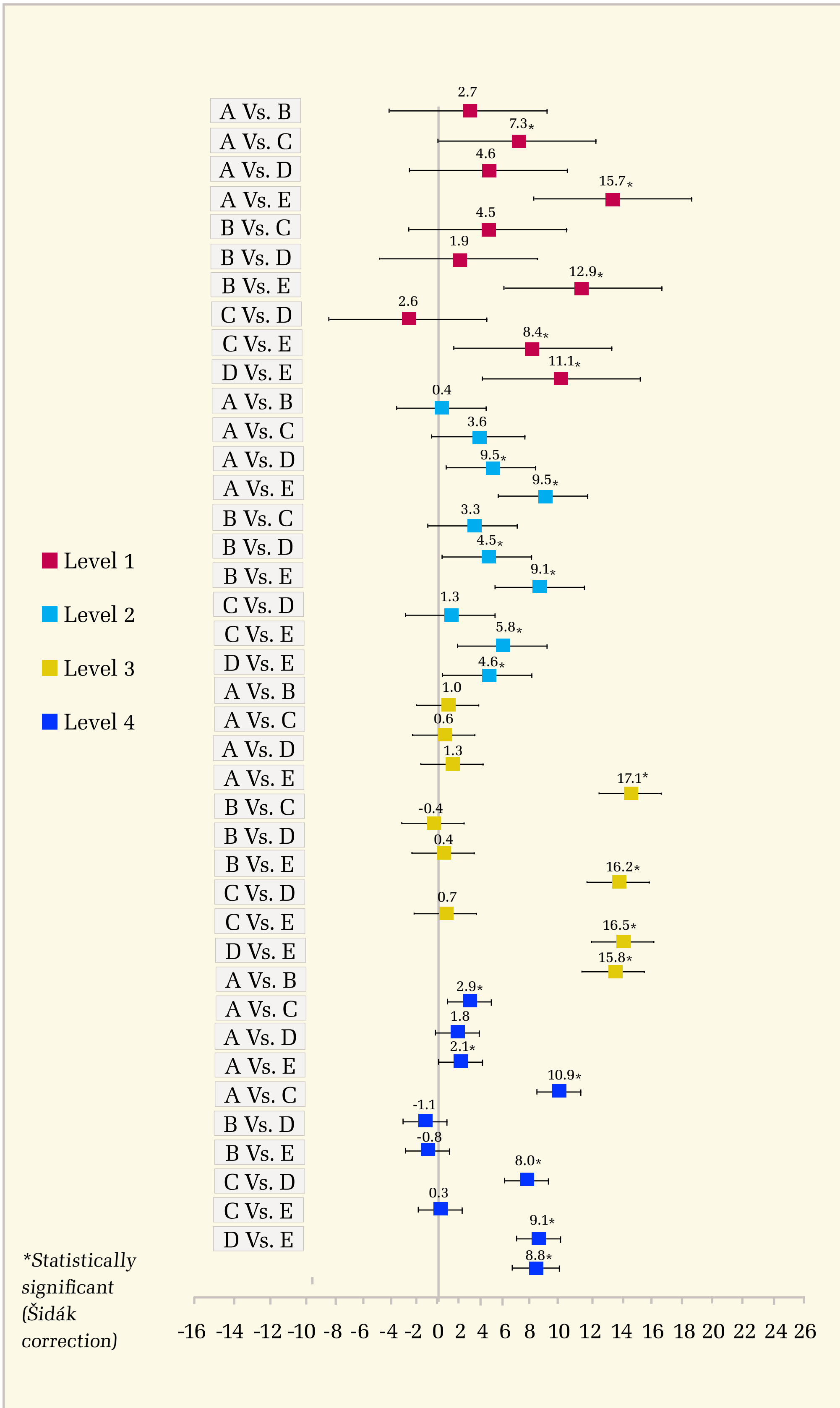

**Table 1**
**Descriptive Statistics**

| | | | PGFA | | PSFA | | PVA | |
|---|---|---|---|---|---|---|---|---|
| **Level** | **Group** | **N** | **Mean (St. dev)** | **Min-Me-Max** | **Mean (St. dev)** | **Min-Me-Max** | **Mean (St. dev)** | **Min-Me-Max** |
| 1 | A | 15 | 94.7 (3.04) | 89.4-95.2-99 | 3.8 (2.07) | 1-3.9-7.4 | 1.5 (1.65) | 0-0.8-6 |
| 1 | B | 15 | 91.9 (7.5) | 67.2-94.9-97.6 | 7.3 (6.99) | 1.4-5.1-30.5 | 1.2 (1.36) | 0-0.5-4.6 |
| 1 | C | 15 | 87.4 (8.52) | 64.3-88.9-97.2 | 10.9 (7.52) | 2.5-10.9-32.4 | 2.4 (1.73) | 0.2-1.9-5.3 |
| 1 | D | 15 | 90.1 (6.84) | 80.2-90.2-99 | 8.4 (5.88) | 0.7-8.3-18.4 | 1.5 (1.26) | 0.1-1.4-3.7 |
| 1 | E | 15 | 79 (6.16) | 60.7-79.4-89.3 | 15.9 (5.54) | 5.7-16.3-29.4 | 5.1 (2.51) | 1.8-4.6-11 |
| 2 | A | 15 | 96.1 (1.97) | 93-96.3-99.2 | 3.2 (2.25) | 0.5- 2.7-6.7 | 0.9 (0.56) | 0-0.9-2 |
| 2 | B | 15 | 95.7 (3.53) | 88-96.8-99.7 | 3.6 (3.22) | 0.5- 2.6-11 | 0.7 (0.96) | 0-0.4-3.7 |
| 2 | C | 15 | 92.4 (4.24) | 83-92.9-98.2 | 5.5 (3.88) | 0-5- 12.6 | 2.1 (2.37) | 0-1.3-9.1 |
| 2 | D | 15 | 91.2 (5.71) | 76-91.8-98.5 | 6.4 (5.51) | 1.1-4.9-24 | 2.4 (2.27) | 0-2.-5.8 |
| 2 | E | 15 | 86.6 (2.41) | 82.6-86.3-91 | 9 (1.58) | 5.3-9.3-11 | 4.4 (1.7) | 1.3-4.8-7 |
| 3 | A | 15 | 98.1 (1.09) | 96-98.3-99.2 | 1.4 (0.98) | 0-1.2-3.1 | 0.5 (0.48) | 0-0.6-1.3 |
| 3 | B | 15 | 97.1 (3.73) | 87.9-98.6-100 | 2.3 (3.24) | 0-1.2-11.9 | 0.5 (0.92) | 0-0.2-3.6 |
| 3 | C | 15 | 97.5 (1.01) | 95.4-97.8-98.8 | 0.9 (0.95) | 0-1-3 | 1.6 (1.16) | 0-1.6-4.6 |
| 3 | D | 15 | 96.8 (2.01) | 92.5-97.6-99 | 2.6 (1.48) | 1-2.1-5.3 | 0.6 (0.7) | 0-0.6-2.2 |
| 3 | E | 15 | 81 (3.66) | 74-81.1-86.3 | 11 (2.69) | 7.2-10-16.3 | 8.1 (3.43) | 4.7-7.6-16.6 |
| 4 | A | 15 | 98.8 (0.84) | 97.1-98.9-100 | 1.1 (0.79) | 0-1-2.9 | 0.2 (0.28) | 0-0-0.7 |
| 4 | B | 15 | 95.9 (2.09) | 92.1-95.6-100 | 2.7 (1.75) | 0-2.5-6.8 | 1.4 (1.89) | 0-1-7 |
| 4 | C | 15 | 97 (1.25) | 95-97.3-99 | 1.9 (1.26) | 0-1.7-4.5 | 1.1 (1.13) | 0-0.6-4 |
| 4 | D | 15 | 96.7 (2.06) | 92.9-97-99 | 2.4 (1.29) | 1-2.4-4.9 | 0.9 (0.97) | 0-0.6-3 |
| 4 | E | 15 | 87.9 (2.79) | 83.2-87.7-92.6 | 7.5 (1.93) | 3.7-7.9-10.3 | 4.6 (1.73) | 1.5-4.7-7.7 |

each level. Multiple comparisons were conducted by applying the Šidák alpha correction. No formal tests were performed for data distribution since, for small sample size, the tests for normality could lead to misleading conclusions. Instead, a graphical exploration of the symmetry of the data was performed.

## Results

Table 1 shows the mean and standard deviation values of PGFA, PSFA and PVA at four different levels for the five experimental groups. At all levels significant differences were found among the five groups in term of pooled PGFA, PSFA and PVA (Table 2, 3, 4). At all levels group E showed a significantly lower PGFA value and a significantly higher PCFA and PVA than all other groups (p<.05).
At the more apical level (2 mm from the apex) group A has a significantly higher PGFA than group C and a significantly lower PSFA than groups C and D (p<.05).
At 4 mm from the apex groups A and B presented a significantly higher PGFA than groups C and D, for PSFA. A significant difference was observed between groups D and A and between D and B, for PVA as well. Finally group B had lower PVA than groups C and D (p<.05).
At 6 from the apex no significant difference was observed in terms of PGFA, PSFA and

**Table 2**

**Analysis of variance for PGFA by level**

| Level | Effect | Num DF | Den DF | F Value | Pr>F |
|---|---|---|---|---|---|
| 1 | Group | 4 | 70 | 12.10 | <.0001 |
| 2 | Group | 4 | 70 | 15.41 | <.0001 |
| 3 | Group | 4 | 70 | 121.18 | <.0001 |
| 4 | Group | 4 | 70 | 72.74 | <.0001 |

**Table3**

**Analysis of variance for PSFA by level**

| Level | Effect | Num DF | Den DF | F Value | Pr>F |
|---|---|---|---|---|---|
| 1 | Group | 4 | 70 | 8.61 | <.0001 |
| 2 | Group | 4 | 70 | 6.60 | 0.0001 |
| 3 | Group | 4 | 70 | 59.24 | <.0001 |
| 4 | Group | 4 | 70 | 45.22 | <.0001 |

**Table 4**

**Analysis of variance for PVA by level**

| Level | Effect | Num DF | Den DF | F Value | Pr>F |
|---|---|---|---|---|---|
| 1 | Group | 4 | 70 | 12.96 | <.0001 |
| 2 | Group | 4 | 70 | 11.03 | <.0001 |
| 3 | Group | 4 | 69 | 54.07 | <.0001 |
| 4 | Group | 4 | 70 | 24.97 | <.0001 |

PVA. At 8 mm from the apex group A had a significantly lower value of PSFA and PVA than group B, and a significantly high PGFA than groups D and B ($p<.05$).
All the contrasts between experimental groups by levels are fully shown in figure 1 ,2, 3.

## Discussion

The obturation of root canal systems is generally accomplished using biocompatible and removable material such as gutta-percha and sealer in order to reduce the presence of voids in so far as possible prevent recontamination of the system (3, 16, 17). Since gutta-percha is a dimensionally stable material over time the PGFA was largely used to evaluate root filling quality (4, 9, 18). In the present study the root canal sections of group E (manual instrumentation and cold lateral obturation technique), at all levels analysed, showed the worst performance: maximum amount of voids and cement and minimum amount of gutta-percha. This widely used obturation technique (19, 20) has been considered a control in several studies (4, 9, 21).
The other four experimental groups were instrumented with two different NiTi system (Wave One Gold and ProTaper Next), both with have a variable taper, a different cross sectional design (parallelogram versus rectangule) and a different motion (reciprocating versus continuous respectively).
Previous studies have investigated the quality of root canal obturation using different techniques (core carrier system versus warm continuous condensation). In general no statistical differences have been found between the two systems (21-23, 10) either in extracted teeth or in simulated C-shaped canals. In a recent *ex vivo* study carrier-based techniques produced a statistically significant difference in terms of PGFA at 4 mm from the working length in oval canals; the authors emphasized the role of both hydraulic and mechanical condensation in order to obtain a tridimensional root canal filling (24).
In the present study, the main difference between the four experimental groups was observed at 4 mm from the apex. At 4 mm, sections of group A resulted in a significantly higher gutta-percha filled area and less of cement compared with groups C and D. With GuttaCore there were greater amounts of gutta-percha, and less sealer and voids than in root canals filled with the Conform fit cone and continuous wave of condensation technique.
As suggested in the literature, using the cold continuous wave obturation system the apical portions of the root canal are more prone to having larger amounts of sealer and voids. Furthermore apical ana-

tomical variations are more difficult to manage using this technique as opposed to the other (18, 23). The results did not reveal any significant difference between groups C and D for any of the analysed parameters (PGFA, PSFA and PVA) when the conform fit cone was used. Type of mechanical instruments used to shape the canals did not seem influence the performance of the cold continuous wave technique with the Conform fit gutta-percha cone. Likewise, when a core carrier system technique was used, the type of instruments did not affect the quality of obturation (group A versus group B), concurring with the results obtained by Schäfer (9). Except at 8 mm from the apex, in the present study, no significant difference was documented in terms of PGFA, PSFA and PVA between groups A and B. At this level the canal shaped with Wave-One Gold resulted in a significantly higher better root filling quality than those shaped with ProTaper NEXT. These results could depend on the instrument design, alloy type and rotation motion (continuous or reciprocating): all of these characteristics lead to a rotational phenomenon known as "swagger" (25). Despite the use of the ProGlider glide path, the loss of centralization preparation could not ensure a good fit of the GuttaCore to the canal walls (26). Finally, in the apical portion of the canals, when WaveOne Gold was used for shaping, GuttaCore insured better root canal obturation in terms of PGFA and PSFA than Conform fit gutta-percha cone and System B. These findings could be due to the various phases of the continuous wave technique (18).

Regarding the detection of voids the present study supports previous findings, root canals filled with the GuttaCore carrier system showed the best results, close to 0 (9, 21).

Within the limitations of the present study, the association of Wave-One and corresponding GuttaCore yielded high quality root filling in extracted teeth, therefore the null hypothesis has been rejected. The quality of obturations in manually instrumented root canals filled using the cold lateral technique was very low.

## Clinical Relevance

The association of reciprocating motion file system shaping and the core carrier system obturation technique produces highly affordable results in terms of PGFA, PSFA and PVA especially in the apical portion of the root canals.

## Conflict of Interest

The authors deny any conflict of interest.


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