THE APICAL ADAPTATION OF DIFFERENT OBTURATION TECHNIQUES: AN *IN VITRO* COMPARAISON OF CARRIER-BASED SYSTEMS WITH WARM VERTICAL COMPACTION

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Abstract

The aim of study was to evaluate the apical adaptation of different obturation techniques by determining the amount of sealer in the apical third of the canal, the presence of obturator at the last one millimeter, the amount of gutta-percha and the presence of plastic carrier at the foramen. One hundred and eight freshly extracted single rooted teeth were divided into four groups: 1) group A: Warm Vertical Compaction "WVC" (VC), 27 teeth; 2) group B: Herofilll® obturators (HF), 27 teeth; 3) group C: Thermafil® obturators (TF), 27 teeth; 4) group D: RealSeal1® obturators (RS1), 27 teeth.
The results showed a significant difference between HF and VC when evaluating the amount of obturation material, the VC having a higher mean (p =0.0001) whereas no significant difference was detected between these two groups in terms of sealer mean area (p=0.268). On the other hand, RS1 showed a higher mean of obturation material (p=0.007) and a lower mean area of the plastic carrier (p=0.025) when compared to TF; these differences were at the 3mm section level. Both HF (p=0.030) and TF (p=0.039) groups had significantly less amount of sealer thickness only at 3mm section level compared to VC group.
RealSeal1® showed the most amount of obturation material and Herofill® showed the least.

Keywords: Carrier-based systems - Thermafil® - Herofill® - RealSeal1® - vertical compaction - leakage.

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L'ADAPTATION APICALE DE DIFFÉRENTES TECHNIQUES D'OBTURATION

Résumé

L'étude vise à évaluer l'adaptation apicale de différentes techniques d'obturation en déterminant la quantité de ciment au niveau du tiers apical (derniers 5mm), la présence de l'obturateur au niveau du dernier millimètre apical, la quantité de gutta-percha et la présence du tuteur en plastique au niveau du foramen. 108 dents monoradiculées fraîchement extraites ont été divisées en quatre groupes: 1) groupe A: compactage vertical à chaud «VC» (VC) (27 dents) ; 2) groupe B: obturateurs Herofill® (HF) (27 dents), 3) groupe C: obturateurs Thermafil® (TF) (27 dents), 4) groupe D: obturateurs RealSeal1® (RS1) (27 dents).
Les résultats ont montré une différence significative entre HF et VC, le VC présentant une moyenne plus élevée (p<0,0001) de la quantité du matériau d'obturation, alors qu'aucune différence significative n'a été décelée entre les deux groupes lorsque l'on a comparé la superficie moyenne du ciment (p = 0,268). D'autre part, RS1 a montré une moyenne plus élevée (p = 0,007) en termes de quantité du matériau d'obturation et une moyenne inférieure de la surface du tuteur en plastique (p = 0,025) par rapport à TF, ces différences étaient au niveau de la section de 3mm. Pour les deux groupes de HF (p = 0,030) et TF (p = 0,039), l'épaisseur du ciment était significativement moindre au niveau de la section de 3mm par rapport au groupe VC.

Mots-clés: Thermafil® - Herofill® - RealSeal1® - compactage vertical - ciment de scellement - technique d'obturation endodontique.

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Introduction

Root canal treatment is achieved by chemo-mechanical debridement of the root canal system followed by filling. The filling material acts as a barrier which prevents the entrance of oral microorganisms and reinfection of the root canal system through microleakage [1].

A number of obturation techniques have been introduced ranging from solid core filling of gutta-percha to softening techniques with either solvents or heat [2]. Flexible and plastic gutta-percha filling techniques have been developed in an attempt to find the best way to obliterate the entire root canal system in three dimensions.

Recently, resin bonding systems have been marketed to provide a better adhesion of the obturation material with the sealer and the dentine; this leads to the formation of a 'monobblock' that increases the resistance to fracture of the tooth [1, 3-5]. These systems, such as RealSeal® (Pentron Clinical Technologies, Wallingford, Connecticut, USA) and Epiphany® (Sybron Dental Specialities, Orange, California, USA), can be placed using lateral or warm vertical compaction or even thermoplastic injection.

Resilon™ material is a thermoplastic synthetic polymer-based root canal filling material. Based on polymers of polyester, Resilon™ contains bioactive glass and radiopaque fillers. It performs like gutta-percha, has the same handling properties, and for retreatment purposes may be softened with heat, or dissolved with solvents like chloroform.

The Thermafil® technique introduced by Johnson in 1987 involves placing alpha phase gutta-percha on a metal carrier heating and using it to obturate the root canal. Currently used carriers are made of stainless steel, titanium or plastic.

Herofill® system (MicroMega) is a 3rd generation endodontic obturator developed to give the practitioner a fast and reliable means of obturating a root canal, and is based on the principle of a solid plastic core coated with thermoplastic.

Literature regarding the carrier-based systems is scarce in general and is limited for the RealSeal1® system in particular.

The aim of this study is to compare the apical adaptation of different obturation techniques: Herofill®, Thermafil® and RealSeal 1® and WVC.

Materials and Methods

108 freshly extracted human teeth were collected from patients visiting the dental care units at the University of Saint Joseph, Beirut-Lebanon, the Jordanian Ministry of Health and two private clinics in Lebanon and Jordan. Roots were flattened and given a length of 16mm. An ISO #10 K-file was introduced into canals to reach the apical foramen. The working length was established at 0.5mm short.

Roots were divided into four groups:

Group A (27 roots): VC "Schilder technique", MMseal® sealer.

Group B (27 roots): Herofill® obturation system, MMseal® sealer.

Group C (27 roots): Thermafil® obturators, AH Plus® sealer.

Group D (27 roots): Real Seal1® obturators system.

In groups A and B, ProTaper™ system was used to create a taper of 8%. The foramen diameter was set at 0.40mm by 2mm over instrumentation using the F2 file. In groups C and D, the Grater Taper (GT™, Dentsply, Tulsa Dental) rotary files were used to obtain the same calibers.

Root canals were prepared under copious irrigation with 5.25% NaOCl; one minute irrigation with 17% EDTA solution to ensure the removal of the smear layer was followed by 3ml irrigation with normal saline.

In group A, classical warm vertical compaction was applied and a #40 McSpadden gutta-percha condenser was used to backfill the coronal two thirds. In groups B, C and D, the roots were filled with the carrier based systems according to the manufacturer's instructions.

Once prepared, each root was embedded in light-cured resin (TechnoVit 7200), cured for 24 hours in a special light curing oven (Exakt 520, Exakt Technologies, Inc., Norderstedt, Germany) using a plastic conical carrier and then sectioned.

In groups B, C and D, the apical part of the roots was preserved for microscopic observation to detect the presence of the plastic obturator at the foramen level. Horizontal sections were obtained with a cutting system (Exakt 300) at the levels of the foramen, 1, 3 and 5 mm coronal to foramen. Sections were done using the lowest speed setting with continuous water cooling to prevent frictional heat and smearing of the filling material that may tend to mask the area of the sealer. All specimens were polished with sand papers mounted on a special rotary machine (Exakt 400 CS) on a pre-determined rotational speed to remove any debris as a result of sectioning excluding the foramen level section. All specimens were digitally photographed (Figs. 1- 4) under an optical microscope (Olympus CX41, Olympus, Japan). Images were then transferred to a computer. Computer software (AutoCad 2007) was used to measure the surface areas of the canals, the obturators, the sealer and the main obturation material (gutta-percha or Resilon®).

Statistical analysis

The statistical analysis was performed using a software program (SPSS for Windows, version 17.0, Chicago, IL, USA). The alpha error was set at 0.05. Variables were tested for normal distribution using Kolmogorov-Smirnov test and for equality of variance using Levene test. One-way ANOVA followed by Tukey post hoc comparisons tests were conducted to explore significant difference in mean between the four groups.

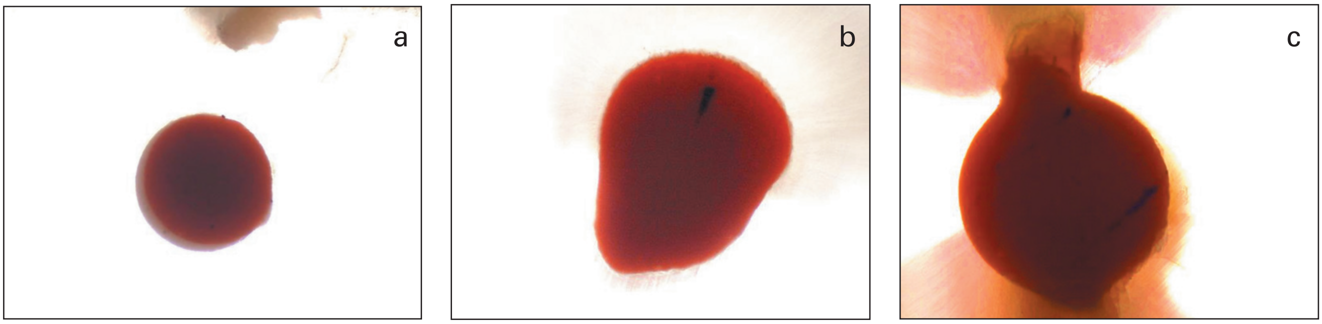

Fig. 1: Warm vertical compaction group sections (a) at 1mm, (b) at 3mm and (c) at 5mm.

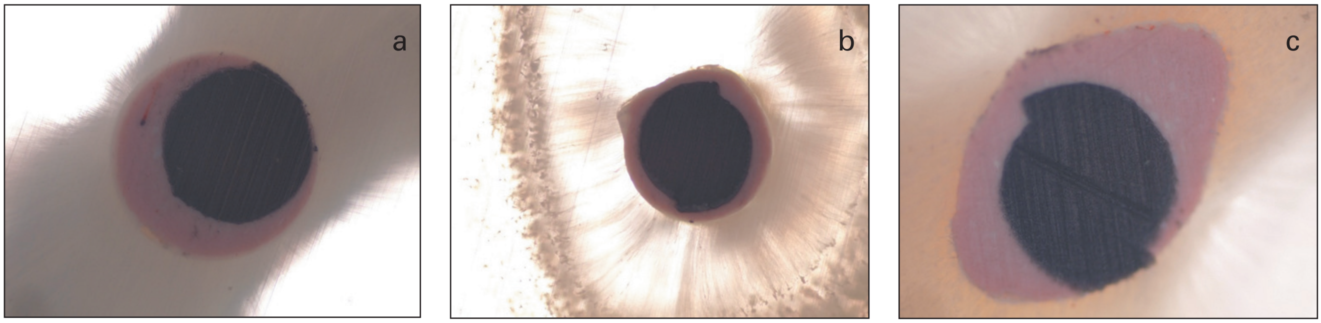

Fig. 2: Herofill® group sections at (a) 1mm, (b) 3mm and (c) 5mm.

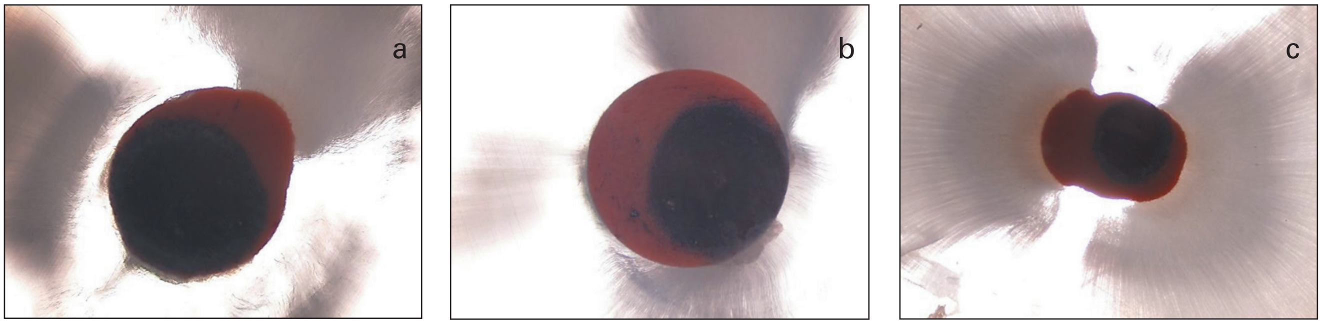

Fig. 3: Thermafil® group sections at (a) 1mm, (b) 3mm and (c) 5mm.

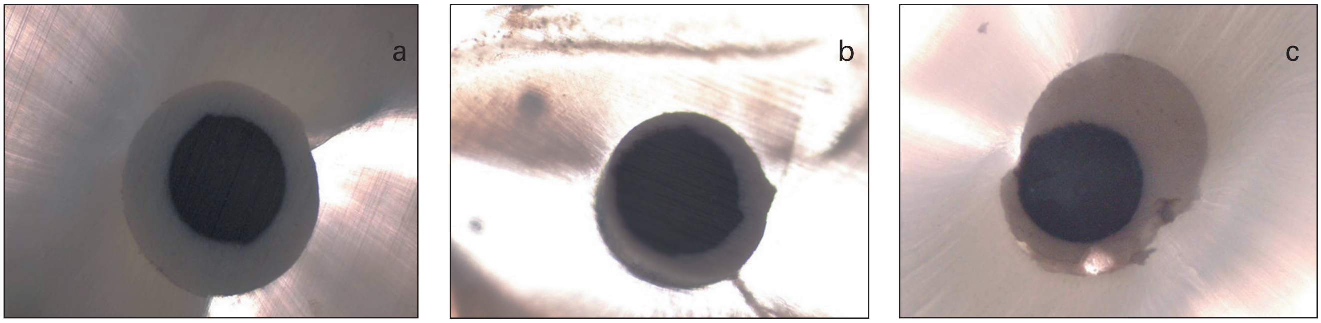

Fig. 4: RealSeal 1® group sections at (a) 1mm, (b) 3mm and (c) 5mm.

Group	Parameter					
	Obturation material		Sealer		Plastic carrier	
	Mean area	S.D	Mean area	S.D	Mean area	S.D
HF	5.8512	3.4267	1.0985	1.5955	9.0409	3.7421
VC	15.6749	14.0608	1.3783	2.0438	-	-
p-values	0.0001*		0.682*			

*Student t-test
Table 1: Comparison of mean areas of obturation material and sealer between the HF and VC groups..

Group	Parameter					
	Obturation material		Sealer		Plastic carrier	
	Mean area	S.D	Mean area	S.D	Mean area	S.D
HF	5.8512	3.4267	1.0985	1.5955	9.0409	3.7421
RS1	13.2393	5.8300	-	-	9.4001	3.6104
VC	15.6749	14.0608	1.3783	2.0438	-	-
TF	8.97764	5.5771	0.7583	1.6665	11.9845	4.5984
P-values	0.000*		0.268*		0.004*	

*Student t test
Table 2: Comparison of the mean areas of obturation material, sealer and plastic carrier between the RS1 and TF groups.

Results

When comparing the mean areas of the obturation materials between VC and HF groups, statistically significant differences were detected between groups (p = 0.000) with the VC group having the highest mean (15.6749); this was consistent at all section levels.
When comparing the mean areas of the sealers used, no statistically significant differences were detected (p = 0.682) except at the 3mm section level (p = 0.001) with VC group having the highest mean (1.2852) as presented in table1.

When comparing the mean areas of the obturation materials in the groups TF and RS1, statistically significant differences were detected between the two groups (p = 0.007) with RS1 having the highest mean (13.2393); this was only significant at the 3mm section level (p = 0.010). When comparing the mean area of the plastic carrier, statistically significant differences were detected (p = 0.025) with the RS1 group having the lowest mean (9.4001); this was only significant at the 1mm section level (p = 0.041) (Table2).

When comparing the mean areas of all the parameters in the four groups combined, statistically significant difference was detected in the mean area of obturation material (p=0.0001) with the VC having the highest mean; this difference was significant at all section levels (p=0.0001). At 1mm, RS1, VC and TF had significantly less amount of obturation material than HF (p =0.0001; 0.0001 and 0.004 respectively). At 3mm level, only HF and TF had less amount of obturation material than VC (p = 0.000 and 0.028, respectively) (Fig. 5).

When evaluating the sealer mean area, no significant difference was found in all sections (p = 0.0268); however significance was detected at the 3mm section level (p = 0.011) with HF and TF having significantly less amount of sealer than VC (p = 0.030 and 0.039, respectively) (Fig. 6).

For the plastic carrier mean area, HF had the lowest mean (p=0.004). This difference was observed at 1 and 3mm section levels (p = 0.026 and 0.023, respectively) as seen in table 3. At 1mm from the foramen, the only significant difference was detected between HF and TF (p = 0.030) with HF having significantly less mean area of plastic carrier. At 5mm, the only significant difference was between HF and TF (p = 0.021) (Fig. 7).

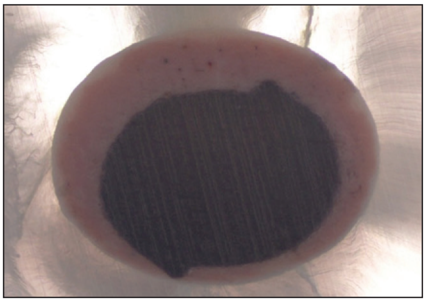

Fig. 5: Dense obturation material (gutta-percha).

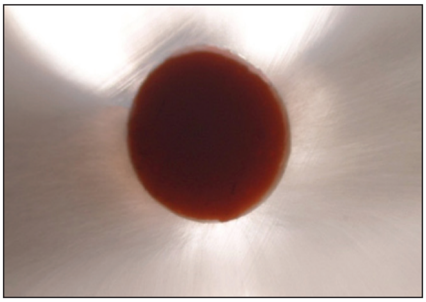

Fig. 6: Sealer film showing between gutta percha and canal walls.

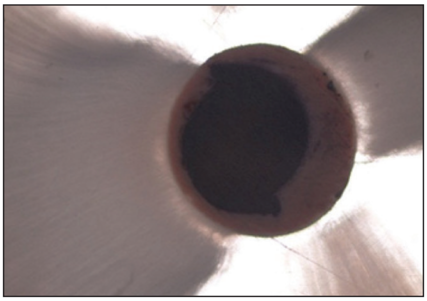

Fig. 7: Plastic carrier.

Group	Parameter					
	Obturation material		Sealer		Plastic carrier	
	Mean area	S.D	Mean area	S.D	Mean area	S.D
RS1	13.2393	5.8300	-	-	9.4001	3.6104
TF	8.97764	5.5771	0.7583	1.6665	11.9845	4.5984
p-values	0.007*				0.025*	

*One way ANOVA
Table 3: Comparison of mean areas of obturation material, sealer and plastic carrier by group at different sections levels.

Discussion

Complete obturation of the root canal system with an inert filling material and the creation of a hermetic, apical seal are considered the optimal goals for endodontic treatment [6]. Since the most common cause of endodontic failure has been attributed to incomplete obturation, many different obturation techniques have been developed in order to increase the success of root canal treatment.

All roots included in this study were prepared to an 8% taper and 0.40mm apical diameter with ProTaper™ and GT™ files systems. The 8% taper was selected to assure the best apical adaptation of obturation materials since it allows the flow of the obturation material into the canal system irregularities and ramifications. In a recent study [7], the 8% taper showed the lowest percentage of voids in comparison to other tapers.
Gutta percha has been the material of choice for obturation since 1867. There are a number of warm gutta-percha methods. These carrier-based systems offer numerous potential advantages, mainly the ease of introduction of the obturation material into the canals' irregularities, thus replicating the intricacies of the root canal system, especially in curved ones. In a study [8] comparing the Herofill® with thermo-mechanical gutta-percha compaction technique with a dye leakage methodology, the authors didn't find any statistically significant difference. However, in our study, a higher mean of obturation material area was observed at the VC group compared to HF. This could be due to the absence of plastic carrier in the VC group. At the 3mm section level, statistically significant difference was detected with the HF having a higher mean area of sealer. In this in vitro study, three carrier-based systems were compared to the warm vertical compaction technique.

Recent advances in obturation materials introduced resins into the filling materials, thus improving root canal adaptation of the filling to the canal walls [7].
Although sealers enhance sealing ability by filling in any residual spaces [9] and bonding to dentine [10] the optimal outcome in obturation is to maximize the volume of the core material and minimize the amount of sealer between the inert core and the canal wall [11, 12].
In their study, Weiss et al. [13] compared the average sealer cement film thickness and the extent and pat-

IAJD Vol. 4 – Issue 1

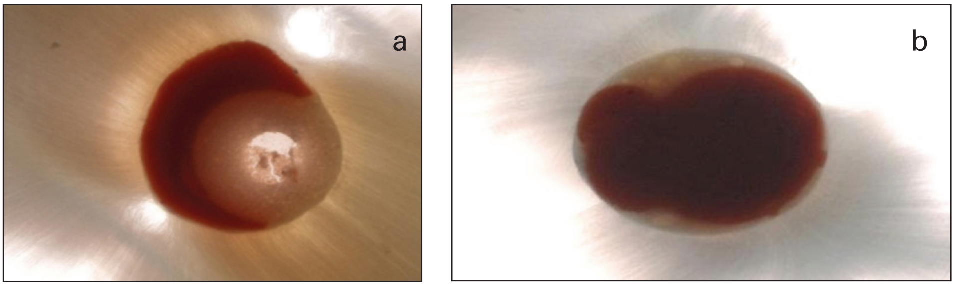

Fig. 8: (a) Massive amount of sealer and the central void; (b) Unsoftened cones.

tern of sealer penetration into dentinal tubules in association with four obturation techniques in curved root canals. Assuming that minimal sealer thickness and fewer voids are good measures of long-term sealing ability, Thermafil® resulted in the best outcome. SimpliFill® resulted in large sealer thicknesses and a high frequency of voids.
In our study, Thermafil® and Herofill® techniques showed the least amount of sealer at the 3mm section level.

The amount of obturation materials in all four groups was significantly different. The study of Gencoglu et al. [14] aimed to detect the apical leakage through a new computerized fluid filtration meter that allowed quantitative measurement of leakage easily. They compared Thermafil®, Soft Core, JS Quick-fill, System B techniques, Microseal and lateral condensation; Thermafil® showed the least leakage among the four techniques without a statistically significant difference. Even though in our study we adopted a different methodology to measure the apical adaptation of the 4 techniques, we found that the Thermafil® system showed a better apical adaptation especially when compared to the Herofill® technique.

The literature available concerning the RealSeal1® obturation system is limited as the system is relatively new. When comparing RS1 to other carrier-based groups in terms of obturation material mean area, at 1mm section level, the RS1 group had significantly higher mean area than HF group but was similar to the TF group. No significant difference was detected with the VC group. At 3 and 5mm sections levels all carrier-based systems were similar as well as with the VC group.
When calculating the sealer mean area, the RS1 group was excluded since the differentiation between the sealer film and the obturation material was impossible due to the tight bond formed leading to the formation of a "monoblock".

The use of heated gutta-percha allows better adaptation to dentinal walls and homogeneity of the filling material [15]. In the VC group, the back-filling of the coronal two thirds of the canals after the downpack was accomplished using a McSpadden gutta-percha condenser size 40. In 21 samples at the 5mm section level, this technique permitted to fill the space in an acceptable manner with a homogenous obturation; a thin layer of sealer was detected. In 6 samples, lack of homogeneity was observed (Fig. 8). In two of the 6 samples, the gutta-percha condenser left a relatively massive amount of sealer at the center of the canal with a small amount of gutta-percha pushed to one of the walls; this could be explained by the extended rotational movement of the gutta-percha condenser in the canal that pushes the softened gutta-percha out of it. In the other four samples, the backfilling cones were barely softened and at least one cone was left unsoftened leaving gaps between the cones and dentinal walls with a relatively large amount of sealer.

The detection of the plastic carrier tip directly at the foramen depends on the pressure applied by the operator during obturation; an excessive pressure might lead to shredding of the obturation material off the carrier leading. Even though no statistically significant difference was observed among the groups, the tip of the plastic carrier was mostly detected at the foramen in the RS1 group (77% of the cases).

Conclusion

Optimal filling of the root canals in three dimensions has paramount importance in prevention of the root canal reinfection.
Among the carrier-based systems themselves, Thermafil® obturation system showed the best outcome especially at the 1mm section level but it had the largest plastic carrier that reflected on the amount of gutta-percha. The RealSeal1® had the smallest plastic carrier and the largest amount of obturation material (Resilon®).

HEROfill® obturation system showed a large amount of sealer especially at the most apical parts (1 and 3mm section levels) with a relatively large plastic carrier and with the least amount of obturation material at the most apical section.

The carrier-based techniques are reliable methods of obturation.

Nevertheless, it would be beneficial to conduct future research and add the new carrier-based system GuttaCore® (Dentsply Maillefer, Baillagues, Switzerland) to such line of research. This new system consists of a cross-linked gutta-percha carrier instead of the traditional plastic carrier. On the other hand, Cone Beam-CT is an important new methodology and could be used in future studies. However, further *in-vivo* studies are beneficial in such line or research and should be considered.

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