A Micro Computed Tomography Assessment of New Carrier-Based Root Canal Fillings

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ABSTRACT

Background: The main aim of the present study is to qualify and quantify voids formation of root canals obturated with GuttaCore (GC) and experimental Hydroxyapatite polyethylene (HA/PE) as new carrier-based root canal fillings by using micro computed tomography scan.

Materials and methods: In the present study, eight straight single-rooted human permanent premolar teeth are selected and disinfected, then stored in distilled water. The teeth decoronated leaving a root length of 12mm each. The root canals instrumented by using crown down technique and the apical diameter of the root canal prepared to a size # 30/0.04 for achieving standardized measurements. A 5mL of 17% EDTA used to remove the smear layer followed by 5mL of 2.5% NaOCl and rinsing with normal saline. Then the shaped root canals were randomly subdivided into two groups of 4 teeth each according to the carrier-based obturation system use, GuttaCore or experimental HA/PE. Afterwards, the obturated roots stored at 37°C with 100% humidity for 72 hours to allow for complete setting of the sealer. Micro-CT was then scanned to quantify the voids within the root canal space. The data were statistically analyzed by one-way ANOVA and post hoc comparison tests (α=0.05).

Results: The root canals obturated with both obturation systems, GuttaCore andexperimental HA/PE showed voids formation, particularly at the apical third of the root canal. GC obturation showed a lower percentage of voids volume (1.54%) than the experimental HA/PE obturation (2.3%). The void volume percentage in the GuttaCore system, however, was non-significantly different (P> 0.05) in comparison with the experimental PE/HA system.

Conclusions: GuttaCore and experimental HA/PE obturators exhibited voids formation within the entire root canal space. The experimental HA/PE obturator is comparable to the GuttaCore obturator in terms of voids qualification

Key words: Obturation, Guttacore, Micro computed tomography, experimental HA/PE. (J Bagh Coll Dentistry 2015; 27(4):21-24).

INTRODUCTION

The success of a root canal treatment depends on three main factors namely, thorough canal debridement, effective disinfection and adequate obturation of the root canal space[(1)]. One of the most critical components in the long term success of root canal treatment is the obturation of the root canal space and the maintenance of a good seal, which leds to a number of new obturating materials with some being lunched commercially in the last decade[(2)].

During obturation of the root canals, athree-dimensional spacehas tobe fluid-tight sealed using suitableprocedures along with appropriate void-free root canal filling materials[(3)]. However, most root canal filling materials do not thoroughly seal the root canal assome voids are frequently created either within root filling material itself or at the material-dentine interface[(4)]. In this situation, possible fluid leakage and bacterial percolation at the root canal interface may therefore be encountered causing periapical lesions and/or failure of the endodontic treatment[(5)].

Carrier based obturation systems is one of the most common techniques used for root canal obturation enhancing, adaptability of warm gutta-percha to the root canal wall and into lateral canals in a controlled and fast manner[(6)]. Several carrier-based obturation systems have been innovated as promising materials for endodontic root canal fillings.

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Over last four years, an obturator-system consisting of a carrier made of cross-linked gutta-percha surrounded by the alpha phase of gutta-percha (Gutta-Core, Dentsply Tulsa Dental, OK) has been introduced on the market to facilitate the endodontic re-treatments. Besides the Gutta-Core (GC), an experimental carrier-based obturation system based on silanated hydroxyapatite and polyethylene (HA/PE) coated with gutta-percha has been recently innovated[(7)].

There is little information on voids measurement of new carrier based obturation systems, Gutta-Core and experimental HA/PE. High resolution micro-computed tomography scan (µCT) has been suggested to evaluate the percentage of volume of voids at the canal wall-obturation material interface and within the obturation material itself[(8-10)]. µCTis a technology used as a research tool in endodontic discipline to study the morphology of the root canal space before and after instrumentation using different types of materials and techniques[(11,12)].

The main aim of the present study is to qualify and quantify the voids volume within the root canal space obturated with new carrier-based root canal filling systems, Gutta-Core and experimental HA/PE using micro computed tomography technology. The null hypothesis of the present study is that the experimental HA/PE obturator is not comparable to the Gutta-Core system in terms of voids qualification.

MATERIALS AND METHODS

Synthesis of the Experimental HA/PE Carrier-Based Obturator:

The preparation of hydroxyapatite/ polyethylene composite core (HA/PE) for carrier-based root canal obturation is performed by a previous study of Al-Hashimi et, al.[7].

Tooth Selection and Instrumentation:

Eight straight single-rooted human permanent premolar teeth selected and disinfected by sodium hypochlorite and then stored in sterile water. Teeth with open apices, root caries, root restoration, root defectsand root resorption were excluded from the study.

A root length of 12mm was achieved by cutting the crown of the tooth with a diamond wheel saw. Access into the canals was performed and a glide path was created by inserting a hand k-file size #10 (Dentsply Tulsa Dental, Tulsa, OK, US) into the canal until it appeared from the apex; this length was calculated and the final working length was fixed at 1mm short of that length. The cleaning and shaping the root canals was carried out with a crown down technique using gates glidden drills size 2, 3 and nickel-titanium hand instruments (DentsplyMaillefer).

The apical diameter of the canal was prepared to size #30/0.04 for achieving standardized measurements. During preparation, irrigation of the root canals was carried out with 2,5 mL of 2,5% sodium hypochlorite. Then the canals were finally flushed with 5mL of 17% EDTA in order to remove the smear layer followed by 5mL of 2.5% NaOCl and rinsing with normal saline.

Obturation of the Canals:

The cleaned and shaped roots were randomly subdivided into two groups of 4 teeth each according to the carrier-based obturation system used.

Group 1: GuttaCore, a metal Verifier (Dentsply Tulsa) corresponding to the size of the final file used (#30/0.04) was placed 0.5mm short of the working length and checked with a periapical radiograph. A thin layer of Tubli-Seal root canal sealer (SybronEndo, Orange, CA, US) was used to coat the root canal walls. The obturator was placed into ThermaPrep® Plus obturator oven to soften the two obturators used and then inserted to the pre-determined working length with slight pressure. The handle of the obturators with the remnants of the obturation material around was removed with a round diamond bur.

Group 2: Experimental HA/PE obturation system. The root canals were obturated in a similar manner to the samples in the Group 1; the main difference is that the temperature used to soften the experimental obturator was reduced to 100°C by the incorporation of a thermo-regulator connected to the current Thermafil® oven to monitor temperature control. Afterwards, the obturated roots were stored at 37°C with 100% humidity for 72 hours to allow for complete setting of the sealer.

Volumetric measurements of the root canal obturation were quantified and qualified using (µCT). Both systems of gutta-core and experimental HA/PEwith the root canal sealer were engaged in the (µCT) assessment for void detection. The percentage of the volume of voids was obtained by dividing the total volume of voids by the total volume of root canal obturation, calculated by the µCT (IP) software (Simple ware®, Exeter, UK). The samples were further characterized by evaluating 3D reconstructions.

RESULTS

Means and standard deviations of total volume and percentage (%) of voids and gaps in the root canal teeth obturated with GC or the experimental HA/PE are shown in Table (1). While, representative two- and three-dimension Micro-CT images showing the voids in the root canal obturated using GC or HA/PE are presented in figures 1A-2A and figures 1B-2B, respectively.

Same lowercase latter indicates no differences in column for the total volume of voids. Same upper-case latter indicates no differences in the overall voids within the root canal filled teeth ($p>0.05$).

The percentage of the volume of voids was obtained by dividing the total volume of voids by the total volume of root canal obturation, calculated by the µCT (IP) software. GC obturation showed a lower percentage of voids volume (1.54%) than the experimental HA/PE obturation (2.3%). Overall, canals obturated with GC presented the lowest percentage of voids, whereas canals obturated with HA/PE showed a higher percentage of voids. The void volume percentage in the GuttaCore system was non-significantly lower ($P> 0.05$) than that of experimental HA/PE system, particularly in the apical region. The data obtained from µCT were analysed with ANOVA followed by Bonferroni post hoc test to compare the means by using SSPS software version 18(SPSS Inc, Chicago, IL).

Table (1). Means and Standard Deviations of Total Volume and Percentage of Voids and Gaps in the Root Canal Filled Teeth

Product	Composition	Total volume of root obturation (mm^3)	Total volume of voids (mm^3)	Overall voids (%)
GuttaCore	Cross-linked gutta-percha	20.04	0.319 ±0.8 [a]	1.54% [A]
HA/PE	Hydroxyapatite-polyethylene	34.70	0.848 ±1.0 [a]	2.3% [A]

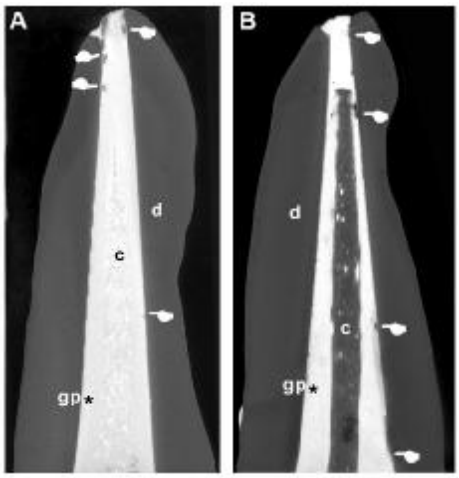

Figure (1): Representative Micro-CT Scans of Single Rooted Premolar Tooth Showing the Voids in the Root Canal Obturation in the Apical, Middle and Coronal Thirds of the Canal for (A) Gutta-Core and (B) Experimental HA/PE. gp: Gutta-Percha; d: Dentine; c: Carrier of HA/PE and GC.

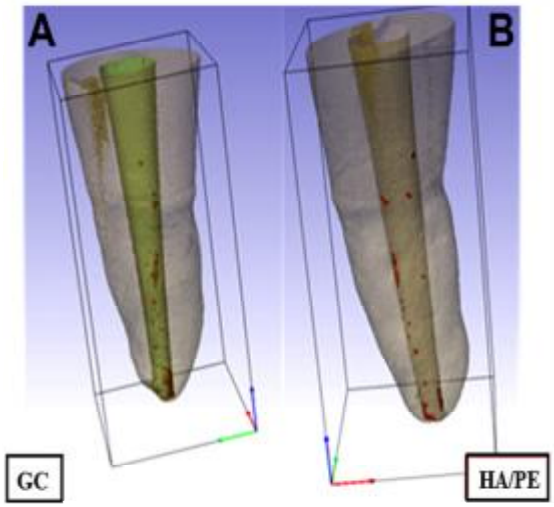

Figure (2): Representative Three-Dimension Reconstruction Model of Micro-CT Images of Single Rooted Premolar Tooth Showing the Voids in the Root Canal Obturation in Apical, Middle and Coronal Thirds of Canal (red) for (A) Gutta-Core and (B) Experimental HA/PE Obturators.

DISCUSSION

Several factors contribute to the success of endodontic therapy. An adequate obturation of the root canal space prevents percolation of microbes into root canal space, favoring the maintenance of a favorable biological environment for healing [(13)]. However, in order to achieve this goal, it is important to useoutstanding high standard obturation materials [(14)].

Although the obturating material is of significant issue in endodontic treatment, the obturation technique has also an important role to play and of the different techniques used, carrier based obturation is one of such method. Two systems of Guttacore and experimental HA/PE were tested as a carrier for gutta-percha to fill the root canal space in three dimensions. The present study aimed at qualifying the voids volume within the root canal space of these two obturation systems using micro-computed tomography technology.

The null hypothesis was rejected as the percentage of volume of voids of the experimental obturator was comparable to that of commercial one, GC. Although the commercial one showed a lower percentage of voids volume than that of the experimental one, the difference remained non-significant statistically. This could be related to the fact that the experimental obturator was not as tapered as the commercial one. The carriers with tapered design are expected to be well-adapted to the root canal walls

Because of the high accuracy, µCT technology with a resolution of 6.5 μm was used in the current study to locate voids and quantify the volume of voids inside the obturated canal. The µCT produced a three-dimensional reconstruction of the root canal fillings and its constituents[(15, 16)]. The findings of µCT scan showed that Guttacore obturation system exhibited a percentage of voids volume around 1.54% within the whole root canal space, whereas HA/PE systems displayed voids at around 2.3%. A lot of voids of such percentage were characterized in apical region of root canals filled teeth. This finding suggests that the apical control of both carrier systems, Guttacore and experimental HA/PE is limited. In conclusion, both carrier-based root canal filling systems

exhibited voids presence within the root canal space particularly in the apical region suggesting limited apical control of the obturator system. In addition, the obturation of root canals with experimental HA/PE is comparable to that of GuttaCore in terms of voids formation.

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