ORIGINAL ARTICLE

3D MICRO-CT ANALYSIS OF QUALITY OF OBTURATION WITH A NANOFLOW ROOT CANAL FILLING MATERIAL

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ABSTRACT

The study aimed to assess the percentage volume of voids in root canals, obturated with NanoFlow and conventional gutta percha using micro-computed tomography analysis at three different levels of the root canal. This study was conducted from June, 2016 to August, 2017 at the Advanced Technology Dental Research Laboratory, King Abdul-Aziz University. Twenty-eight mesial roots of extracted mandibular first molars were prepared with Protaper Universal rotary instruments, randomly assigned into two groups (n=14) and filled with either NanoFlow or conventional gutta percha and AH26 using continuous wave of condensation technique. Samples were stored at 37°C and 100% humidity for one month and then scanned with high-resolution micro-CT scanner. None of the two obturation materials provided a void-free filling. The mean percentage volume of voids in the NanoFlow group was (1.49%) and in the conventional gutta percha group was (2.22%) at the apical area of the canal. NanoFlow had significantly less percentage volume of voids at the apical third of the canal than the conventional gutta percha (p= 0.016).

Key Words: *micro-CT, NanoFlow, Obturation, Voids, Endodontics, Gutta Percha*

INTRODUCTION

It has been reported in studies that one of the main objectives of endodontic treatment is to prevent re-infection of the root canal space by providing a dense three-dimensional (3D) obturation following the cleaning and shaping process.[1-5] Dense 3D obturation serves the purpose of obliterating microbial infection within the root canal space.[6] One of the primary causes of root canal treatment failure is attributed to a lack of adequate filling; whereby the presence of voids serves as pathways for bacterial migration and canal contamination.[2] In order to avoid re-infection of root canal system and subsequent root canal treatment failure, biologically inert materials are used to completely and densely fill the root canal space.[7] These materials typically come in the form of gutta percha (GP) and root canal sealer and can be used in a number of ways to fill the root canal space.[7] However, conventional filling materials are associated with a significant disadvantage in the form of an absence of fluid tight seals[8], due to which they often contain voids that adversely affect the treatment outcome. Thus, recent developments in the field of endodontics have seen the introduction of a nano-based warm GP material by NanoFlow technology that incorporates the use of nano-molecular technology to provide a highly superior three-dimensional obturation as compared to conventional filling materials.[9] It was claimed that the nano-based GP was relatively dense and lower in working temperature and had reduced levels of volumetric changes as compared to conventional filling materials.[9]

Within the field of endodontics, micro-computed tomography analysis (micro-CT) is a tool that is frequently utilized in void measurement within root canal filling materials.[10-12] Micro-CT works by incorporating the use of X-rays in order to provide multi-slice 2D or 3D volumetric images of the area of interest.[13] Micro-CT is a non-invasive and non-destructive approach[13]; thus, enabling a more precise void measurement as compared to histologic assessments.[10-12] Furthermore, this technique allows for adequate examination of the internal anatomical structure of the tooth from various angles of interest.[13] However, there is a lack of research incorporating the use of micro-computed tomography in the evaluation of voids, present in nano-based GP. This study; therefore, aimed to target this gap by assessing the percentage volume of voids in root canals obturated with NanoFlow™ and conventional GP using micro-computed tomography analysis at the coronal, middle, and apical levels of the root canal. The null hypothesis tested that there was no difference in the percentage volume of voids found in both filling materials at the three different canal levels.

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MATERIALS AND METHODS

Samples selection

This experimental study was conducted from June, 2016 to August, 2017 at the Advanced Technology Dental Research Laboratory, Faculty of Dentistry, King Abdul-Aziz University, Jeddah, Saudi Arabia. Ethical approval was obtained from the local ethical committee (#052-16). For this study, extracted human mandibular first molar teeth were collected as samples. These samples were then cleaned and disinfected. Buccolingual and mesiodistal radiographs were taken to evaluate the anatomy of all extracted mesial roots of the molars. Samples displaying calcification or abnormal anatomy were excluded from this study. Twenty-eight matched mesial roots of mandibular first molars with two separate canals were used. The roots were completely formed with closed apices and a less than 30^{o} curvature, and free from cracks or external root resorption. The distal roots were sectioned and removed, and the teeth were decoronized in order to standardize the length of the canals to 16mm. Finally, the roots were stored in a saline solution.

Canals Preparation

Canals were explored to patency and working lengths were determined using K file #10 (Dentsply, Maillefer, Ballaiges, Switzerland). The file was inserted in the canal with light pressure until the tip appeared at the patent apical foramen and the working length was calculated by subtraction 1mm of the file length. All the samples were prepared by an experienced operator using a Protaper Universal rotary instrument according to the manufacturers' instructions (Dentsply Maillefer, Ballaigues, Switzerland) to size F2 apically. Sodium hypochlorite irrigation (3 ml) was used after each file, and a final flush of 2 ml of 17% EDTA solution was used followed by 1 ml of saline. The canals were dried using paper points. Finally, the samples were randomly assigned into two experimental groups (n=14 each).

Canal obturation

Continuous wave of condensation technique was utilized in both groups. AH Plus sealer (Dentsply, Maillefer, Ballaiges, Switzerland) was prepared according to manufacturer's instructions. A small amount of the sealer was placed on the tip of a pre-fitted F2 gutta-percha cone and introduced into each root canal. Master cone radiographs were taken for all samples. Group 1 was filled with AH Plus sealer and a Protaper Universal F2 (Dentsply, Maillefer, Ballaiges, Switzerland) gutta-percha cone. The gutta-percha was down-packed with a System B heat source (SybronEndo, Orange, CA, USA) within 3mm from the working length. Then, the canal was back-filled using Obtura II (Spartan Fenton, MO, USA). Group 2 was filled with AH Plus sealer and an ultra-flow NanoFlow™ F2 (Healthdent, USA) gutta-percha cone. The gutta-percha was down-packed with a System B heat source (SybronEndo, Orange, CA, USA) within 3mm from the working length. Following the manufacturer's instructions, the canal was back-filled with low melting point NanoFlow (Flow 150, Healthdent, USA) gutta-percha pellets using a new Obtura II gun (Spartan Fenton, MO, USA) in order to avoid material contamination. Periapical radiographs were taken for all the roots to confirm obturation homogeneity and apical extension. The teeth were stored at 37°C and 100% humidity for one month to ensure the setting of the sealer.

Micro-CT Evaluation and Analysis

All the specimens of groups 1 and 2 were mounted on a customized silicon mount in order to standardize their position for the micro-CT. Following instrumentation and obturation, each tooth was scanned twice using the same scanning parameter. The scanning was carried out using a SkyScan 1072 high-resolution micro-CT (Skyscan, Aartselaar, Belgium). The specimens were scanned under conditions of 100 kV source voltage, 100 µA beam current and an isotropic pixel size of 11µm. This resulted in 900–1100 transverse cross-sections per specimen using 0.5 mm Al/Cu filter. The rest of the settings were according to the manufacturer's instructions.

For evaluation, each specimen root was divided into three equal thirds, namely the apical, middle and coronal sections. The mean volume of the root canal filling (gutta-percha and sealer) and the mean volume of internal and external voids were calculated in cubic micrometers within each third using the micro-CT analysis. The ratio between the volume of voids/gaps and the total filling volume was then calculated. This data was collected and statistically analyzed using the Mann – Whitney U test and Wilcoxon test (SPSS, version 20; SPSS, Chicago, IL, USA). The level of significance was set at 0.05. Using the Mann-Whitney U test, the differences between the two independent specimen groups on the basis of a single ordinal variable and no specific distribution (14) was used to analyze the null hypothesis. The same null hypothesis was analyzed using Wilcoxin Signed Rank Test, which uses paired samples to analyze the data.

RESULTS

In the present study, neither of the two obduration materials provided a void-free filling (Figure 1). The mean percentage volume of voids in both groups at the three different root canal levels is presented in Table 1. The results indicated that NanoFlow had significantly

TABLE 1: DESCRIPTIVE DATA AND MANN – WHITNEY U TEST TO COMPARE THE MEAN PERCENTAGE VOLUME OF VOIDS BETWEEN BOTH GROUPS

	GP		NanoFlow		
Regions	Mean	SD	Mean	SD	Sig
Coronal	2.3003	.00077	2.0994	.42317	.168
Middle	2.3079	.01788	2.0822	.46308	.158
Apical	2.2203	.81334	1.4924	.55837	.016
Total	6.8297	.81673	5.6755	1.12021	.014

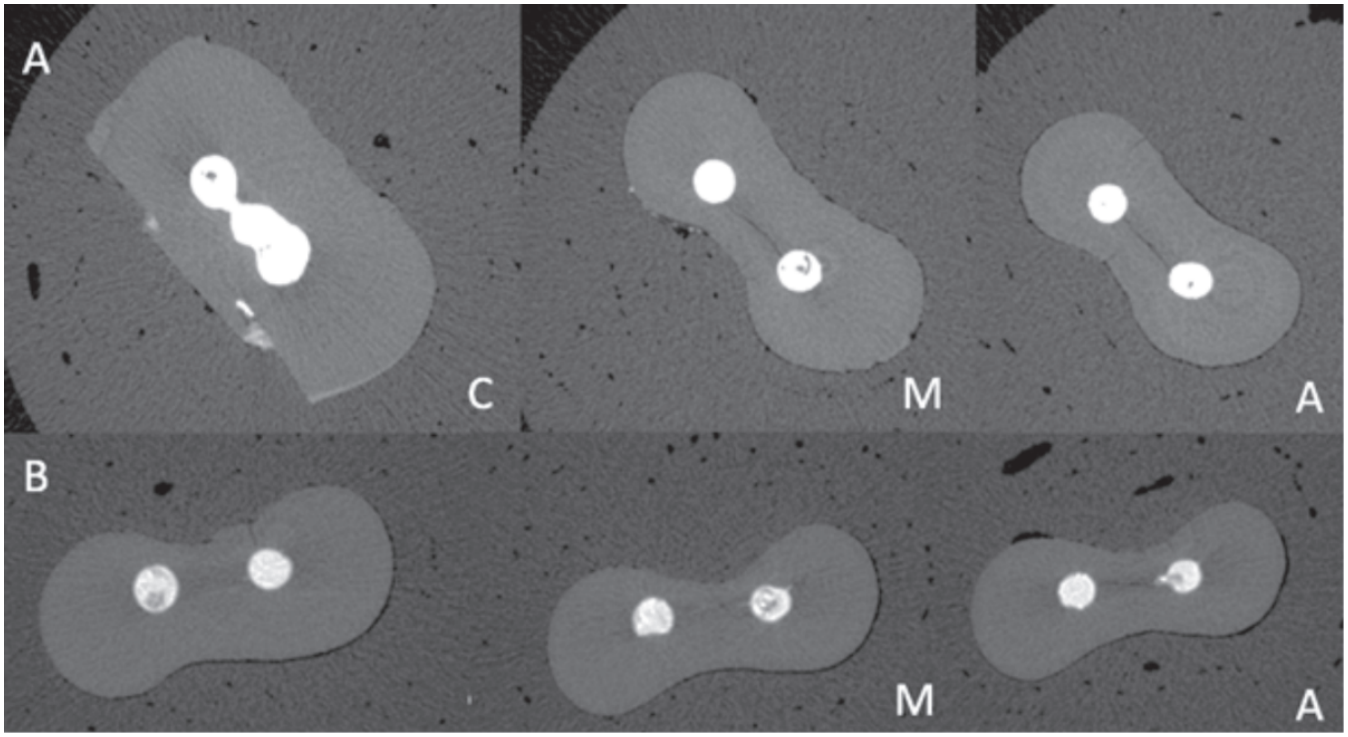

Fig 1: Two-dimensional image of three-dimensional reconstruction of root canals obturated with conventional gutta percha (A) and NanoFlow (B) fillings and cross-sections at three different levels of the root canals; coronal (C), middle (M) and apical (A) showing internal voids in both groups.

less percentage volume of voids at the apical third of the canal than the conventional gutta percha (p= 0.016) (Table1).

Comparison of the mean percentage volume of voids within each material at the three different levels showed no statistical significant difference (conventional gutta percha group (p= 0.33), NanoFlow group (p= 0.07).

DISCUSSION

This study aimed to investigate the difference between the percentage volume of voids in root canals obturated with NanoFlow and conventional GP using micro-computed tomography analysis at the coronal, middle and apical levels of the root canal. Thorough evaluation of the obtained results indicated that neither nano-based GP nor conventional GP provided a void-free filling. These findings were similar to previous investigations conducted within this regard.[11,14-17] Specifically, there was a difference between the measurements of apical third in NanoFlow and conventional GP filling materials, and the null hypothesis was rejected.

Our result found that the use of NanoFlow as a filling material yielded significantly fewer voids at the apical level of the root canal as compared to conventional GP. This might be due to the superior properties of the nano-molecular technology. The low working temperature of NanoFlow aids in reducing shrinking during the heating-cooling cycle and crystalline phase changes of the GP molecule.[9]

Additionally, the study revealed that the percentage void volume in the apical area of both materials was less compared to the coronal and middle levels of the

root canal system. However, this change was not statistically significant within each material. A reason for this slight difference could be attributed to the raised pressure within the apical region during the obturation process. This pressure aided in improving the ability of the material to adapt and helped in reduction of voids.[1]

The results may be constrained by several factors that have the potential to affect the presence of voids within the root filling materials. Most of these factors were standardized within this study and included the operator experience, anatomical configuration of the root canal, and canal preparation quality and technique. Other factors include the sealer type, amount and consistency, as well as the obturation technique.[11] We recommend the conduction of further investigations involving larger sample sizes.

CONCLUSION

The results of the study concluded that neither of the two materials provided a complete void-free root canal filling or obtuation, within the conditions and standards set by the conducted investigation. However, NanoFlow gutta-percha resulted in less voids in the apical region of root canal as compared to the conventional gutta-percha.

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REFERENCES

1 Gandolfi MG, Parrilli AP, Fini M, Prati C, Dummer PM. 3D micro-CT analysis of the interface voids associated with Thermafil root fillings used with AH Plus or a flowable MTA sealer. International endodontic journal. 2013 Mar 1;46(3):253-63. doi: 10.1111/j.1365-2591.2012.02124.x.

2 Gilhooly RM, Hayes SJ, Bryant ST, Dummer PM. Comparison of cold lateral condensation and a warm multiphase gutta-percha technique for obturating curved root canals. International endodontic journal. 2000 Sep 1;33(5):415-20.

3 Al-Dewani N, Hayes SJ, Dummer PM. Comparison of laterally condensed and low-temperature thermoplasticized gutta-percha root fillings. Journal of endodontics. 2000 Dec 1;26(12):733-8.

4 Villegas JC, Yoshioka T, Kobayashi C, Suda H. Three-step versus single-step use of system B: evaluation of gutta-percha root canal fillings and their adaptation to the canal walls. Journal of endodontics. 2004 Oct 1;30(10):719-21.

5 Venturi M. Evaluation of canal filling after using two warm vertical gutta-percha compaction techniques in vivo: a preliminary study. International endodontic journal. 2006 Jul 1;39(7):538-46.

6 De-Deus G, Brandão MC, Fidel RA, Fidel SR. The sealing ability of GuttaFlow™ in oval-shaped canals: an ex vivo study using a polymicrobial leakage model. International endodontic journal. 2007 Oct 1;40(10):794-9.

7 De Moor RJ, Hommez GM. The long-term sealing ability of an epoxy resin root canal sealer used with five gutta percha obturation techniques. International endodontic journal. 2002 Mar 1;35(3):275-82.

8 Jung M, Lommel D, Klimek J. The imaging of root canal obturation using micro-CT. International endodontic journal. 2005 Sep 1;38(9):617-26.

9 Keleş A, Alcin H, Kamalak A, Versiani MA. Micro-CT evaluation of root filling quality in oval-shaped canals. International endodontic journal. 2014 Dec 1;47(12):1177-84.

10 Kierklo A, Tabor Z, Petryniak R, Dohnalik M, Jaworska M. Application of microcomputed tomography for quantitative analysis of dental root canal obturations. Advances in Hygiene & Experimental Medicine/Postepy Higieny i Medycyny Doswiadczalnej. 2014 Jan 1;68.

11 Verma P, Love RM. A Micro CT study of the mesiobuccal root canal morphology of the maxillary first molar tooth. International endodontic journal. 2011 Mar 1;44(3):210-7. Doi:10.1111/j.1365-2591.2010.01800.x

12 Hammad M, Qualtrough A, Silikas N. Evaluation of root canal obturation: a three-dimensional in vitro study. Journal of endodontics. 2009 Apr 1;35(4):541-4.

13 Angerame D, De Biasi M, Pecci R, Bedini R, Tommasin E, Marigo L, Somma F. Analysis of single point and continuous wave of condensation root filling techniques by micro-computed tomography. Annali dell'Istituto superiore di sanita. 2012 Jan;48(1):35-41.

14 Moeller L, Wenzel A, Wegge-Larsen AM, Ding M, Kirkevang LL. Quality of root fillings performed with two root filling techniques. An in vitro study using micro-CT. Acta Odontologica Scandinavica. 2013 Jan 1;71(3-4):689-96.

15 Love RM, Jenkinson HF. Invasion of dentinal tubules by oral bacteria. Critical reviews in oral biology & medicine. 2002 Mar;13(2):171-83.

16 da Silva LA, Nelson-Filho P, da Silva RA, Flores DS, Heilborn C, Johnson JD, Cohenca N. Revascularization and periapical repair after endodontic treatment using apical negative pressure irrigation versus conventional irrigation plus triantibiotic intracanal dressing in dogs' teeth with apical periodontitis. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics. 2010 May 1;109(5):779-87.

17 Wu MK, Van Der Sluis LW, Ardila CN, Wesselink PR. Fluid movement along the coronal two-thirds of root fillings placed by three different gutta-percha techniques. International Endodontic Journal. 2003 Aug 1;36(8):533-40.