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Evaluation of CPoint obturation system for voids & gaps using digital microscope

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Abstract

Aim: This study was aimed to evaluate the quality of CPoint obturation system by calculating the percentage of surface area of voids and gaps in different levels in comparison with Guttapercha point/GuttaFlow 2 and Guttacore/Endofill.

Method: Sixty palatal roots of extracted upper first molars were prepared and divided into three groups of 20 samples each, the first group was obturated with CPoint/BC sealer, the second one was obturated with Guttapercha point/ GuttaFlow2 and the third was obturated with GuttaCore/Endofil. Each root sectioned into four sections at 8 mm, 6 mm, 4 mm, and 2 mm levels from the W.L and transferred to be photographed under digital microscope, the canal cross sectional area, and the area of voids and gaps were measured then surface area percentages of unfilled areas were calculated. Data then analyzed statistically using ANOVA and LSD tests.

Results: Higher percentages of unfilled areas were observed in Group1 ($p < 0.01$) in comparison to Group2 and Group3 except with S2 of Group3 ($p > 0.05$). And there was no significant difference between Group2 and Group3 except at S2. The results of comparison among different sections within each group showed that there is a highly significant difference ($p < 0.01$) between S2and (S8, S6, S4) within Group 1, in Group 2 the results showed that there is a highly significant difference between S8 and the other sections, and also showed a significant difference ($p < 0.05$) between S2 and (S4, S6).

Within Group 3 the results revealed significant difference between the (S4, S6) and the (S8, S2) sections.

Conclusion: All systems showed voids and gaps and CPoint obturation system showed the highest percentage of unfilled areas and level of root section had an effect on voids and gaps distribution.

Keywords: CPoint, GuttaCore, GuttaFlow 2, Voids, Gaps

Introduction

Ideal endodontic obturation result in successful treatment **(1)**, as it was reported that the reason of 60% of endodontic failure is an incomplete root canal filling **(2)**, so the presence of voids and gaps may negatively affect the endodontic treatment outcome, the voids within obturation material may be less significant than gaps present in interferences between dentin-sealer or core-sealer because micro-organisms, if exist, will be imbedded in an unfavorable environment without access to nutrition in contrast to the peripheral gaps which are considered a favorable environment for micro-organisms and act as channels for their passage to peri-radicular tissues, and fluid ingress which allow sealer dissolution **(1)**.

Many obturation systems have been developed such as Carrier-based obturation systems that have shown the most promising results **(3)**, with minimum voids **(4)**. Carrier-based obturation system was introduced in 1978, used endodontic files coated with guttapercha, so that the carrier can rapidly condense the material both laterally and vertically **(5, 6)**. Metal carriers were later replaced with plastic one coated with alpha-phase GP, heated in special oven, then a third-generation carrier called GuttaCore (Dentsply Tulsa Dental Specialties) was developed; it consists of cross-linked gutta-percha instead of plastic to be more easily removed and is sufficiently rigid to guide the gutta-percha into the root canal **(7).**

GuttaFlow 2 (Coltène/Whaledent, Langenau, Germany) is a cold flowable obturation system available in a dual-barrel syringe, combines finely ground guttapercha powder and polydimethylsiloxane based sealer. The material shows good flow properties and 0.2% expansion on setting to enhance canal sealing quality **(8)**.

A water expandable obturation system (CPoint) is the most recent advancement in root canal filling (Endotechnologies, LLC). The system composes of premade cone of different tip sizes and tapers with accompanying paste, the central core of CPoint cones made of mix of proprietary nylon polymers: Trogamid T and Trogamid CX providing cone flexibility and rigidity, the flexibility is important to be easily inserted into the canal curvatures while rigidity is for easily passage in tiny canal to the working length, the outer surface of the core is coated with cross-linked copolymer of acrylonitrile and vinylpyrroli which has been polymerized and cross-linked using allyl methacrylate and a thermal initiator **(9)**. The premade obturation point absorbs the moisture present in dentinal tubules to expand laterally in non-uniform way without axial expansion. To fill the spaces left between canal wall and obturation point, a resin based or calcium silicate based sealers must be used with this system such as EndoSequence bioceramic sealer (BC sealer) (Brasseler USA, Savannah, GA) which is a premixed, injectable sealer with nanoparticles to be able to flow into canal irregularities and dentinal tubules. The sealer also shows high sealing ability as it chemically bonds to canal dentin **(10).** Little is known about the quality of this new obturation system, so further studies are needed to evaluate its ability to seal canal space in comparison to other systems.

Obturation quality was assessed by several methods, one of them is to identify the areas of voids and gaps by examination of root sections using digital microscope **(11).**

Materials & Methods

Samples selection and Biomechanical Preparation

Sixty extracted human upper first molars free of root caries, fracture, and resorption were selected for this study, and diagnostic radiographs were taken to confirm the presence of single straight palatal canal, mature apex with no signs of internal resorption, calcification or pervious endodontic therapy. The length of palatal roots was standardized at 10 mm. This study was approved by the scientific committee of Department of conservative Dentistry, College of Dentistry, Mustansiriyah University, Baghdad, Iraq.

Using barbed broach, the pulpal tissue was removed and the apical patency was confirmed with size10 K-file. Also the size10 K-file was used to determine apical foramen location by inserting the file into the canal until it was visualized at the apical foramen and the working length was established by subtracting 1mm from root length. Size 15 K-file was used to determine the initial size of the canal, only roots with initial file size 15 K-file were included in the study **(12).**

Crown down technique was used to prepare the canals with Protaper Next system (Dentsply Maillefer, Switzerland) to size X4 which was operated by Endo-motor (NSK- Japan), the program was set at 300 rpm and 2 Ncm torque. At first, the canals were irrigated with 1 ml 2.5% NaOCl, and size 15 K-file was introduced to full working length to obtain a glide path then with small strokes a reproducible glide path was confirmed. Glyde (METABIOMED CO.LTD, Korea) was introduced in the canal orifice and instrumentation procedure was started with X1 file followed by X2, X3 and finally with X4. The files were used with brushing motion for no more than 3-4 sec and used for five times then discarded, between each file the canals were recapitulated with size 15 K-file to maintain apical patency and irrigated with 1ml of 2.5% NaOCl using Irrigation needles (Cerkamed, Poland) which were inserted until resistance was faced, and then reduced 1 mm to prevent canal obliteration **(13)**.

When the instrumentation procedure was completed, 5 ml of 2.5% NaOCl used to irrigate the canals, then 3 ml of 17% EDTA was applied for 3 min to remove the smear layer before flushing with 2.5% NaOCl, followed by copious amounts of distilled water to remove the remnants of irrigating solutions and then dried with size 40/ 06 paper points **(14)**.

The roots were randomly divided into 3 groups (n =20) according to type of obturation materials: Group 1: obturated with CPoint obturation cones & Endosequence BC sealer (Single cone technique); Group 2: obturated withGuttapercha point & GuttaFlow 2 sealer (single cone technique); Group 3: obturated withGuttacore obturator & Endofill sealer (core carrier system)

Root canal obturation

Group 1: The root canals were dried with paper points, Size 40/06 CPoint verifier (Endo technologies, LLC, Shrewsbury, MA, USA) was used to check length and tug-back. Syringe cap from EndoSeuence BC Sealer syringe (Brasseler, Savannah, USA) was removed and securely intra canal tip was attached with a clockwise twist to the hub of the syringe, the tip was marked at one third and inserted into the canal no deeper than the coronal third, the plunger was pressed while slowly withdrawing the tip from the canal, a small amount (1-caliberation markings) of BC sealer was dispensed then a single point size 40/06 CPoint was used and its coronal end trimmed with scissor to flush with canal orifice,then buttered with sealer and slowly inserted to canal full length using endodontic plugger, any material excess was removed with cotton pledget moistened with water.

Group 2: In this group the Automix GuttaFlow 2(Coltene/ Whaledent, Germany) was used with guttapercha. After root canals were dried with paper points, the GuttaFow 2 applicator was removed and replaced with flexible mixing tip. After slight pressure on plunger the material flows homogeneously mixed at a ratio of 4:1 from mixing tip. GuttaFlow 2 was spread on the mixing slab and inserted into root canal with master file #40 then the master cone X4 coated with sealer and inserted to the working length. Excess guttapercha and sealer was removed with a hot plugger.

Group 3: In the third group, Endofill sealer (Produits Dentaires SA, Switzerland) was used with GuttaCore X4 obturators (Dentsply Tulsa Dental Specialties, USA). The root canals were checked with a size verifier corresponding to the last file which is X4, the verifier was taken to working length and rotated in the canal 360 degree to check its passivity, then the canals were dried with paper point. Endofil sealer was mixed according to manufacturer instructions, on a dry clean cement slab, until a homogenous creamy mix was formed, size 40/ 06 paper points was coated with sealer to brush the coronal third of the canal then the excess of material was removed with second paper point. X4 Guttacore obturator was placed in the obturator holder of Thermaprep 2 oven then the holder was pushed down and obturator size in the oven was selected and start button pressed to initiate obturator thermoplasticization, after seconds the oven was beeping indicating that the obturator was ready for using so the obturator was removed and placed into the canal with pressing downward movement to canal's full length. The obturator handle and excess material extruded from the orifice was removed by bending the handle right and left.

The roots radiographed to ensure obturation length and stored at 37 C and air humidity of 100%.

Root sectioning and image capture

To facilitate the sectioning procedure and roots handling, the roots were poured in clear orthodontic acrylic, The sectioning procedure was made using diamond disk of 0.3 mm in thickness in sectioning device, with regarding to the apical 1mm that would be discarded with the base, as the W.L was 1mm short of the apex**,** and to include the coronal surface of the first section in study, four cuts were made horizontally to obtain 4 sections (8, 6, 4, 2) of 2 mm in thickness for each group.

Each group provided (80) test specimens consisting of (20) specimens from each root region, each segment was marked at its coronal side with fine fissure bur and indelible marker to ensure microscopic capturing of coronal side; one dot for (8 mm) segment, 2 dots for (6 mm) segment, 3 dots for (4 mm) segment and 4 dots for (2 mm) one. The sectioning procedure was executed with water cooling to avoid the softening of the obturation materials and to reduce smearing**.**

Each root section was taken to be captured under digital microscope (Dino-Lite), the coronal surfaces of samples were captured**,** at 180X magnification and the microscope was fixed at 1.5 cm away from the sample **(Figures: 1, 2 and3)**. The images then transferred to (Adobe.Photoshop.CC.2014v15.x64) for analysis with the aid of magnetic lasso tool used to trace and measure the cross sectional area of the canal and the area of the unfilled areas (voids, gaps) for each section, then the percentages of unfilled areas to canal area were calculated by this formula: (Unfilled areas/cross sectional canal area × 100)

Statistical analysis

SPSS version 21 was used to perform statistical analysis. ANOVA & LSD tests were used to analyze the percentages of voids and gaps areas at significance level of 5%.

Results

CPoint/ BC sealer group showed the highest voids & gaps percentages which differed significantly with canals obturated with Guttapercha point/ GuttaFlow 2 & those obturated with GuttaCore/ Endifill at the coronal & middle sections (S8, S6, S4), while at the apical section (S2), the study showed highly significant differences ($p < 0.01$) between CPoint/BC & Guttapercha/GuttaFlow 2, and between Guttapercha/GuttaFlow 2 & GuttaCore/Endofill as shown in Table (1)
The results of comparison among different sections within each group is demonstrated in Table (2)

Discussion

The quality of root canal obturation is decisive in successful endodontic treatment as the complexity of canal system makes the complete disinfection of accessory canals, isthmuses and irregularities not possible, so the microorganisms and their toxins must be blocked with appropriate three dimensional root filling to prevent its flow to periapical tissues **(15).**

CPoint was developed as a simple obturation system which is a cone and sealer obturation technique.The hygroexpandable cone is consisting of copolymers of acrylonitrile and vinyl pyrolidine hydrogel coats the carrier made of nylon **(16),** the copolymers are crosslinked by allyl methacrylate which is also decrease the hydrogel dissolution and hardening it to limit the absorption of water; this hydrogel is hydrophilic enhancing absorption of dentinal moisture, so the obturation point swells gradually after placement **(17),** adapts to the canal and seals the gaps by pushing the BC sealer to the irregularities, isthmuses and accessory canals. The Endosequence Bioceramic sealer used in this study as recommended by Endotechnologies, LLC as it is the best companion product to be used with their product. Bioceramic is non-resorbable sealer and hydrophilic; uses the dentinal moisture to set, realsing hydroxyapatite and calcium hydroxide as byproduct making the sealer a biocompatible and antibacterial **(18, 19).**

In this study, the CPoint was compared with gold standard obturation material (gutta-percha) when used as cold and warm obturation system. GuttaFlow 2 was chosen as cold obturation system due to its unique expansion property and excellent physical and chemical characterstics **(20)**. Core carrier obturators are warm obturation system that was selected to be tested; because of its ability to fill the canal three-dimensionally and as the adhesion between the carrier and core is essential; the GuttaCore therefore was selected to be studied due to its novel enhancement; which is the cross-linked gutta-percha core **(21)**.

The novel ProTaper Next files (DENTSPLY Tulsa Dental Specialties, Tulsa, USA) were used in this due to its asymmetric rectangular cross-section and offset design that ensure two-point contact with the walls thus creating large space for the debris removal **(22)** that may reduce the possibility of voids formation.

Although the disadvantages associated with the methodology of root sectioning and quality assessment using digital microscope and software but it was used in this study to detect the unfilled areas rather than conventional radiography because the latter is unable to detect the voids smaller than 300 um **(23)**; or CBCT which is also not accurate in voids detection **(24),** additionally the method used in this study is simple; don't need for sections treatment **(25).**

In this study GuttaFlow 2 with master cone showed the lowest mean of voids and gaps percentages which could be attributed to the expansion of GuttaFlow 2 material on setting, homogeneous composition and good flowability because of guttapercha nanoparticles that increase its wetting ability, adaptation to the gutapercha cone and penetration into dentinal tubules **(26).** The usage of master cone also played a role in reducing the possibility of voids and gaps in this group as it helped in pushing the material toward the canal irregularities enhancing its adaptation to the canal anatomy furthermore increasing core material and reducing sealer amount thus reduces the frequency of voids and in turn reduces the possibility of communication between them **(27).** GuttaCore revealed a non-significant difference with GuttaFlow2 as the GuttaCore obturator can condense the softened gutta-percha 3-dimensionally into canal micro-irrigularities. In this system the hydraulic force allows the sending of the filling material in lateral and apical directions without vertical or horizontal condensation **(28).** Besides the gutta-percha expansion when used with eugenol in short and long period **(29)**. In the apical section there was a highly significant difference between the two systems and this finding could be justified to the non-centered core within the volume of guttapercha coating and material stripping in the apical third **(30)**.

GuttaFlow 2 with master cone demonstrated a highly significant difference with CPoint obturation point and its companion BC sealer at all sections, the explanation of this finding is the voids that happened to the later due to its expansion behavior. The unlimited swelling of HEC causing rupture and tearing in the hydrogel coating which composed of network of chains of cross-linked polymer, also this system showed a gap at the cone- sealer interface that may be due to the water extraction from the point by the BC sealer (**17**); as this calcium silicate based sealer is hydrophilic and the water present in the canal acts an important role in sealer setting **(31)**, leaving a delamination behind.

The study showed that the apical section within Group 1 has a highly significant difference with other sections, suggested that the cone is snugly fit into the apical third of the canal with limited expansion of the point; reducing the possibility of material defects and decreased amount of the sealer in this section that may take part in the cone shrinkage.

Within GuttaFlow2 group, the lowest voids & gaps percentages was found at the apical section with significant difference compared to the coronal and middle, the explanation for this result is that the apical third received GuttaFlow2 material first with master cone ensuring the minimum voids & gaps in this section, besides the accurate fitting of the master cone in the apical third reduced the sealer volume with associated voids occurred due the entrapment of air during material manipulation and insertion. Furthermore, the occurrence of sealer voids depends on physical properties of the sealer **(32, 33),** which explain the highest percentages of voids in coronal and middle segments as GuttaFlow 2 has high surface tension, also there is no chemical bonding between GuttaFlow 2 and guttaperch cone; this may be the cause of the presence of gaps at the interface **(34).** Coronal section has a highest means of voids & gaps percentages, revealing a highly significant difference with the other three sections within this group which may be due to the use of hot instrument for the excess removal; the heat soften the guttaperch entrapping air in its mass.

Within GuttaCore group the coronal and apical sections showed the highest mean of voids & gaps percentages without significant difference between them, the coronal section revealed this finding because of the main disadvantage of this system which is the eccentrically located carrier and non-uniform distribution of gutta-percha volume around it, with the extrusion effect created while insertion because of the friction between canal wall and obturator; the guttaperch retained coronally **(35)**. For the same reason the apical third showed this consequence which is the carrier exposure due to the material stripping. While at the middle sections, the hydraulic force produced by the carrier enhance the flow of thermoplasticized gutta-percha and compact it well against canal fins, so the these sections showed a significant difference with the apical section and also with coronal one as this hydraulic pressure condensed the material evenly better than the hand condensation that is used coronally after the removal of carrier.

Conclusion

Single cone obturation technique using Guttapercha point/ GuttaFlow 2 is the preferred systemt as it can result in homogeneous obturation mass with expansion property of GuttaFlow 2.

Moreover, it is easy to use and doesn't need compaction forces that in turn reduces the possibility of root fracture. There is also no need for heat with its disadvantages and required equipment for warming.

conflict of interests:

There is no conflict of interests in the products or companies described in this article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Table (1): LSD test for mean value of voids and gaps percentages between three groups at each section.

Sections	Groups		Mean difference	S.E	P-Value
S8	Group 1 (CPoint)	Group 2 (GF2)	0.57826	0.11748	0.000 (HS)
		Group 3 (GC)	0.51942	0.11748	0.000 (HS)
	Group 2 (GF2)	Group 3 (GC)	0.05883	0.11748	0.618 (NS)
S6	Group 1 (CPoint)	Group 2 (GF2)	0.77729	0.09441	0.000 (HS)
		Group 3 (GC)	0.94035	0.09441	0.000 (HS)
	Group 2 (GF2)	Group 3 (GC)	0.16306	0.09441	0.090 (NS)
S4	Group 1 (CPoint)	Group 2 (GF2)	0.86941	0.11279	0.000 (HS)
		Group 3 (GC)	0.67051	0.11279	0.000 (HS)
	Group 2 (GF2)	Group 3 (GC)	0.19889	0.11279	0.083 (NS)
S2	Group 1 (CPoint)	Group 2 (GF2)	0.64686	0.14317	0.000 (HS)
		Group 3 (GC)	0.04846	0.14317	0.736 (NS)
	Group 2 (GF2)	Group 3 (GC)	0.69533	0.14317	0.000 (HS)

Table (2): LSD test for mean value of voids and gaps percentages between the different sections within each group.

Groups	Sections		Mean Differences	S.E	P- Value
Group 1	S8	S6	0.11093	0.11244	0.327 (NS)
		S4	0.15737	0.11244	0.166 (NS)
		S2	0.57018	0.11244	0.000 (HS)
	S6	S4	0.04644	0.11244	0.681 (NS)
		S2	0.45925	0.11244	0.000 (HS)
	S4	S2	0.41280	0.11244	0.000 (HS)
Group 2	S8	S6	0.30996	0.08782	0.001 (HS)
		S4	0.44852	0.08782	0.000 (HS)
		S2	0.63879	0.08782	0.000 (HS)
	S6	S4	0.13856	0.08782	0.119 (NS)
		S2	0.32882	0.08782	0.000 (HS)
	S4	S2	0.19026	0.08782	0.033 (S)
Group 3	S8	S6	0.53186	0.14696	0.001 (HS)
		S4	0.30847	0.14696	0.039 (S)
		S2	0.00229	0.14696	0.988 (NS)
	S6	S4	0.22339	0.14696	0.133 (NS)
		S2	0.52957	0.14696	0.001 (HS)
	S4	S2	0.30617	0.14696	0.041 (S)

Figures:

1-Microscopic images for sample obturated with CPoint / BC sealer.
2-Microscopic images for sample obturated with Guttapercha point/ GuttaFlow 2
3-Microscopic images for sample obdurated with GuttaCore/ Endofill

Figure 1

Microscopic images for sample obturated with CPoint / BC sealer

Figure 2

Microscopic images for sample obturated with Guttapercha point/ GuttaFlow

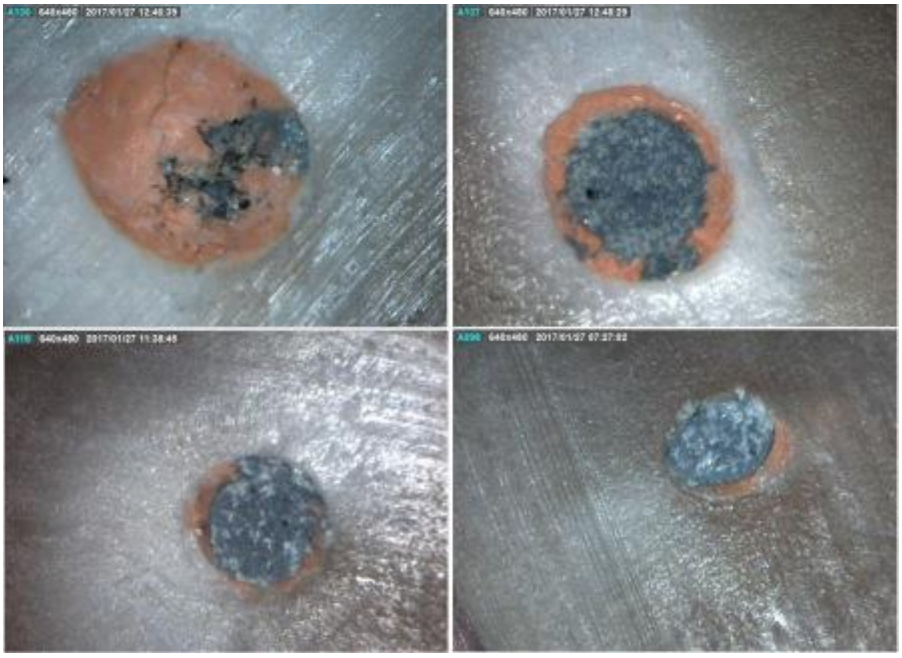

Figure 3

Microscopic images for sample obdurated with GuttaCore/ En