Original Article

Sealing ability of three single-cone obturation systems: An *in-vitro* glucose leakage study

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Abstract

Aim: The aim of this study is to compare the corono-apical sealing ability of three single-cone obturation systems using a glucose leakage model.

Materials and Methods: A total of 90 extracted maxillary single rooted teeth were selected and their crowns were cut. The root canal of each sample was instrumented using a rotary crown down technique and then divided into four experimental (n = 20 each) and two control groups (n = 5 each). Samples in the experimental groups were filled as follows: Group 1, cold lateral condensation using Gutta-percha/AH Plus; Group 2, single-cone Gutta-percha and AH Plus; Group 3, single-cone Gutta-percha/and GuttaFlow2; Group 4, single-cone Resilon/RealSeal SE after 7 days, the sealing ability of root canal fillings was tested at different time intervals using glucose leakage model. Glucose leakage values were measured using a spectrophotometer and statistically analyzed.

Results: The four experimental groups presented significantly different glucose leakage values at all test periods ($P < 0.05$). At the end of the observation period, the cumulative glucose leakage values of Groups 3 and 4 were significantly lower than those of Groups 1 and 2 ($P < 0.05$).

Conclusion: Gutta-percha/GuttaFlow2 or Resilon/RealSeal SE combinations provided the superior sealing ability over the lateral condensation technique.

Keywords: GuttaFlow2; microleakage; obturation techniques; RealSeal SE

INTRODUCTION

The purpose of the root canal obturation is to provide a tight seal that prevents reinfection of the canal and subsequent leakage of fluid and antigenic agents into or from the periradicular tissues.[1] Nowadays, there is increasing demand for prompt, simple and efficient obturation technique, which improves practice and causes less stress for patients and clinicians. With the widespread use of rotary NiTi instruments and matched-taper Gutta-percha cones, the single-cone obturation technique has become popular.[2]

With the aim of improving the marginal sealing properties of root canal filling, new root canal filling systems have been recently developed such as RealSeal SE and GuttaFlow2 systems, which may encourage the practitioners to use the single-cone obturation technique.

The ReaSeal SE system consists of a self-etching methacrylate sealer and Resilon core material. It is claimed to reduce the application steps of the ordinary epiphany system, thus becoming a more user-friendly material and bonds to both the Resilon core and radicular dentin through hybrid layers on both substrates leading to a monoblock unit, which may prevent leakage and improve the root strength.[3]

GuttaFlow2 (Coltene/Whaledent, Altstätten, Switzerland) is a cold flowable; self-curing material and composed of Gutta-percha powder, polydimethylsiloxane and nano silver particles. It has a better seal and good adaptability because of its high flowability and setting expansion.[4]

The sealing ability is a basic feature that needs to be tested for every root canal filling material or technique. A variety of laboratory-based experimental methods are used to detect and measure leakage along root fillings. These methods include dye penetration, spectrometry of radioisotopes, fluorometric and electrometric methods,

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Date of submission : 29.05.2013
Review completed : 26.08.2013
Date of acceptance : 13.09.2013

Access this article online

Quick Response Code:

Website: www.jcd.org.in

DOI: 10.4103/0972-0707.120936

bacterial penetration and fluid transport model.[5] Xu *et al.* discussed a new non-destructive model that measures the leakage of glucose molecules quantitatively by using a spectrophotometer.[5]

The aim of the present study was to evaluate coronoapical microleakage along root canal fillings using glucose leakage model by comparing three matched-taper single-cone filling systems with cold Gutta-percha lateral compaction technique using glucose leakage model at different time intervals. The following combinations were used as a single-cone filling technique: Gutta-percha/AH Plus, Gutta-percha/GuttaFlow2 and Resilon/RealSeal SE.

MATERIALS AND METHODS

Samples preparation

A total of 90 freshly extracted human maxillary incisors with sound roots were used. The crowns were cut below the cemento-enamel junction so that the length of roots was standardized at 15 mm. The working length was determined and the canals were instrumented by Profile NiTi rotary instruments (Dentsply Maillefer) to size 35/0.06 using the crown-down technique. The canals were irrigated after using each file with 5 ml of 3% sodium hypochlorite (NaOCl) solution using Vibringe® ultrasonic dental irrigation syringe (medgadget) and a 27-gauge Max-i-Probe needle (Dentsply Maillefer). After finishing the instrumentation, the prepared canals were rinsed with 5 ml of 17% ethylenediaminetetraacetic acid (EDTA) solution for 2 min followed by 10 ml distilled water as final irrigation to remove any traces of NaOCl.

Samples grouping and root canal obturation

After drying all canals, the samples were divided according to the obturation technique and materials into four experimental groups of 20 samples each and two control groups of 5 samples each [Table 1]. Samples in the negative control group did not receive root canal fillings while in the positive control group they were obturated with a single-cone Gutta-percha size 35/0.06 but without sealer placement.

In Group 1, AH Plus sealer was mixed according to the manufacturer's instructions and applied into the prepared root canal using a lentulo spiral size 25. A master Gutta-percha cone of size 35/0.02 was coated with sealer and placed into the root canal to the full working length. Lateral condensation was achieved using size 25/0.02 standardized Gutta-percha cones and size C finger spreader (Dentsply Maillefer). Excess Gutta-percha was cut at the orifice level with a flame-heated hand plugger and vertically compacted.

In the other experimental groups (Single-cone obturation technique), each sealer was prepared and placed into prepared canals according to manufacturer's instructions. The tip of the matched taper cone (Gutta-percha or RealSeal point) was dipped into the sealer and placed slowly in up and down motion until reaching the full working length. The coronal excess of the master cone was cut to coronal orifice using a flame-heated hand plugger. In the RealSeal group, the coronal surface of the obturation was light cured after 5 min for 40 s. All samples were incubated for 1 week at 37°C and 95% humidity to allow complete setting of sealers.

Microleakage measurement

The roots in the experimental and positive control groups were coated with triple layers of nail varnish, except at the coronal end and apical 1 mm of the root end. The roots in the negative control group were entirely covered with nail varnish.

Microleakage along the root canal was evaluated using the glucose leakage model as described by Xu *et al.*[5] The concentrations of leaked glucose (mg/dl) were measured after 1 day and then after 1, 2, 3, 4 and 6 weeks with a Glucose kit (Glucose Liquid, Quimica Clinica Applicada S.A) in a spectrophotometer (Beckman Du 520, Coulter, Germany) at a wave length of 505 nm.

Statistical analysis

The results were statistically analyzed by Kruskal-Wallis and Mann-Whitney tests. To compare leakage at different times within each group, Freidman and Wilcoxon signed ranks tests were used. All level of statistical significance was set at a *P* value less than 0.05.

RESULTS

The negative control group showed no detectable

Table 1: Samples grouping and materials used for root canal filling

Groups	N	Obturation technique	Materials	Manufacturer
Group 1	20	Lateral condensation	Gutta-percha (0.02 taper)+AH Plus sealer	Diadent, Dentsply, Germany
Group 2	20	Single-cone	Gutta-percha (0.06 taper)+AH Plus sealer	Diadent, Dentsply, Germany
Group 3	20	Single-cone	Gutta-percha (0.06 taper)+GuttaFlow2	Diadent, Coltène Whaledent, Germany
Group 4	20	Single-cone	Risolon (0.06 taper)+ReaslSeal SE	Syrbon Endo, USA
Positive control	5	Single-cone	Gutta-percha (0.06 taper) no sealer	Diadent
Negative control	5	No obturation	Nil	Nil

glucose leakage throughout the experiment while the positive control group had immediate substantial glucose leakage, which increased over time. This indicates that the seal of the glucose leakage system was effective and reliable.

The mean values and statistical comparisons between the experimental groups at each time interval are given in Table 2. After the 1st day onward, there were significant differences between the experimental groups (Kruskal Wallis test, $P < 0.05$). The results of the Mann-Whitney test indicated that there was no significant difference between Groups 1 and 2 throughout the test period. After the 1st day, the highest glucose leakage was observed in Group 3. After the 1st week, the lowest glucose leakage was observed in the 4th Group. Starting from the 3rd week onward, the lowest glucose leakage was observed in the Groups 3 and 4.

Statistical comparisons between glucose leakage values within each group are presented in Table 3. There was a progressive and significant increase in the glucose leakage values in all experimental groups (Friedman test, $P < 0.05$).

DISCUSSION

In the present study, the leakage along root canal fillings was measured by the glucose penetration method, which is simple and could give reliable quantitative leakage measurements. Single-rooted teeth with single patent root canals were selected for the current study to minimize variations of canal anatomy. The canal diameter was standardized to ISO size 35/06 at apical constriction to have more uniform preparation for most canals. Furthermore, the teeth were resected at the cemento-enamel junction to simplify and standardize the instrumentation and obturation procedures.

One of the methods previously described for improving the root canal seal is the removal of the smear layer before filling.[6] For this reason, the smear layer was removed in the current study by irrigating the root canals after instrumentation with 17% EDTA. Passive ultrasonic irrigation was used in the current study to enhance the efficacy of the irrigating solutions and smear layer removal.[7] The cold later compaction was used in the current study as a standard to which the other single obturation techniques were compared.

The reactivity of obturating materials with glucose could affect the results of the glucose leakage test. The results Shemesh *et al*. indicated that all materials used in the current study did not show glucose reactivity.[8]

The results of this study indicate that all obturation systems allow variable degrees of glucose leakage. The glucose leakage values of AH Plus groups either with lateral condensation or single-cone technique were significantly higher at the end of the experimental period. This might be explained by the fast setting and subsequent polymerization shrinkage of AH Plus sealer,[9] the lack of bonding between this sealer and Gutta-percha,[9] the low penetration ability of this sealer within the dentinal tubules[10] and its hydrophobic property that prevents good adaptation of to the incompletely dried canal.[11]

Table 2: Comparison between glucose leakage mean values (mg/dl) of experimental groups at specific time interval

Groups	Glucose concentration, mg/dl (mean±standard deviation)*					
	1 day	1 week	2 weeks	3 weeks	4 weeks	6 weeks
Group 1	0.56±1.01^{a}	5.02±1.51^{a}	6.40±2.18^{ac}	9.29±3.44^{a}	13.65±5.21^{a}	18.29±5.66^{a}
Group 2	0.56±0.97^{a}	5.31±2.30^{a}	5.46±3.41^{ab}	9.15±4.63^{a}	12.04±3.73^{a}	19.62±8.99^{a}
Group 3	1.73±1.43^{b}	4.67±2.01^{a}	4.59±4.22^{b}	6.20±3.56^{b}	7.27±3.93^{b}	11.95±4.04^{b}
Group 4	0.00±0.00^{c}	2.23±1.43^{b}	9.22±2.90^{c}	7.33±1.88^{ab}	6.64±4.34^{b}	13.14±4.49^{b}
Kruskal Wallis test (*P*)	0.000	0.000	0.000	0.024	0.000	0.000

*Mann-Whitney test: Means with the same superscript letters within each column are not significantly different at $P \geq 0.05$

Table 3: Comparison between glucose leakage mean values (mg/dl) of different time intervals for each experimental group

Times	Glucose concentration, mg/dl (mean±standard deviation)*			
	Group 1	Group 2	Group 3	Group 4
1 day	0.56±1.01^{a}	0.56±0.97^{a}	1.73±1.43^{a}	0.00±0.00^{a}
1 week	5.02±1.51^{b}	5.31±2.30^{b}	4.67±2.01^{b}	2.23±1.43^{b}
2 weeks	6.40±2.18^{b}	5.46±3.41^{b}	4.59±4.22^{b}	9.22±2.90^{c}
3 weeks	9.29±3.44^{c}	9.15±4.63^{c}	6.20±3.56^{c}	7.33±1.88^{d}
4 weeks	13.65±5.21^{d}	12.04±3.73^{c}	7.27±3.93^{c}	6.64±4.34^{d}
6 weeks	18.29±5.66^{e}	19.62±8.99^{d}	11.95±4.04^{d}	13.14±4.49^{e}
Friedman test (*P*)	0.000	0.000	0.000	0.000

*Wilcoxon Signed Ranks test: Means with the same superscript letters within each column are not significantly different at $P \geq 0.05$

The current results indicated a similar glucose leakage patterns in Groups 1-3 and showed a progressive increase in glucose concentrations with time. In Group 4 (RealSeal SE), the glucose leakage pattern was inconsistent throughout experimental periods. After 1 day, no glucose leakage was observed and this may be explained by 5 min delaying the light curing of RealSeal, which might allow the sealer to flow within the dentinal tubules with a subsequent decrease in the polymerization shrinkage and formation of monoblock.[12] After the 1st week, slight increase of glucose leakage was observed, which became significantly evident after the 2nd week. This might be explained by the weak bond between Resilon and RealSeal SE.[13] A significant decrease of glucose leakage was observed after the 3rd and 4th week which may be due to the expansion of RealSeal SE sealer and Resilon by water absorption.[14] After the 6th week, a significant abrupt increase in the glucose leakage was observed again which can be attributed to the higher solubility and bond deterioration of RealSeal SE sealer with time.[15]

The glucose leakage of RealSeal SE group was lower than that of Groups 1 and 2 at the last 3 weeks. This result is matching with the results of a previous study despite methodological variation.[16] This may be due to the higher flow rate, dual curing and hydrophilicity of RealSeal SE sealer.[17] However, some authors did not find a significant difference between the sealing ability of Gutta-percha/AH Plus and Resilon/Epiphany combinations.[18] However, some leakage and push-out studies found that the epoxy resin sealers had better sealability and bond strength.[6,19] The causes of these differences may be attributed to the method of obturation technique and leakage assessment.

The overall lowest mean values for glucose leakage of GuttaFlow2 group may be attributed to setting expansion, high flow rate and lower solubility of this material.[20] In spite of using different methodologies and obturation techniques, the better sealing ability of GuttaFlow over AH Plus was supported by the finding of a previous study.[21,22] However, Brackett *et al.* found that the sealing ability of GuttaFlow/gutta-percha using the single-cone technique and AH Plus/Gutta-percha using the warm vertical compaction or continuous wave technique was similar.[23] However, some authors found that the sealing ability of AH Plus was better than that of GuttaFlow.[24]

CONCLUSION

Within the limitation of this study the following conclusions could be drawn:

1. All obturation techniques used in the current study did not prevent leakage showed a progressive increase in the glucose leakage values over time.
2. Root canals filled with matched taper single-cone technique utilizing RealSeal SE or GuttaFlow2 system allowed the lowest corono-apical glucose penetration with no significant difference between them.
3. Matched taper single-cone obturation technique could be an alternative to the cold lateral condensation technique.

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How to cite this article: El Sayed MA, Taleb AA, Balbahaith MM. Sealing ability of three single-cone obturation systems: An *in-vitro* glucose leakage study. J Conserv Dent 2013;16:489-93.

Source of Support: Nil, **Conflict of Interest:** None declared.