Biomedical & Pharmacology Journal, June 2019. Vol. **12**(2), p. 849-856

A Comparative Mircoleakage Assessment in Root Canals Obturated by Three Obturation Techniques using Fluid Filtration System

Pravin R. Lokhande*, S Balaguru and Deenadayalan

Mechanical Department, Vel Tech Rangarajan Dr. Sagunthala R and D Institute of Science and Technology, Chennai 600 062, India.
*Corresponding author Email : pravinrlokhande@gmail.com

http://dx.doi.org/10.13005/bpj/1709

(Received: 02 November 2018; accepted: 11 April 2019)

The aim of this study was to assess the micro leakage in three root canal obturation techniques viz. Warm vertical condensation, Cold lateral condensation and Thermafil using fluid filtration system. In this study the fluid filtration method is fabricated and used to assess the micro leakage in gutta-percha material obturated using three obturation techniques viz. Warm vertical condensation, Cold lateral condensation and Thermafil. The assessment system which can quantify the micro leakage present into the obturated root canal cavity is today's vital need to improve the further progress in endodontics and conservative dentistry. 45 No's of samples were taken for study and categorized into three, Category I: 15 No's of samples obturated using warm vertical condensation, Category II: 15 No's of samples obturated using cold lateral condensation and Category III: 15 No's of samples obturated using Thermafil. All obturated samples were tested using the fluid filtration system. The DSLR 1200D Canon and Auto CAD by Auto Desk were used to record the bubble displacement in the micropipette. The micro leakage reading are shown in Table 2 and tabulated values showed that Category II: 15 No's of samples obturated using cold lateral condensation, showed highest micro leakage value highest micro leakage followed by Category III: 15 No's of samples obturated using Thermafil and Category I: 15 No's of samples obturated using warm vertical condensation. Category III shown moderate leakage value. The study indicated that micro leakage evaluation using the fabricated fluid filtration system is most reliable quantitative method. On the basis of comparison of micro leakage assessment of three obturation techniques it is found that warm vertical condensed sample having least leakage over the Thermafil and Cold lateral condensation. The reason for micro leakage is shrinkage of gutta-percha during solidification to cause gap in between obturation material and canal wall which can be avoided by providing shrinkage allowance.

Keywords: Root Canal Obturation, Obturation Techniques, Sealing Ability, Micro Leakage Evaluation Techniques in Endodontics.

The root canal obturation is done to save the partially damaged teeth of human jawbone. The substrate from the infected canal is removed and followed by shaping of the canal to develop logical cavity. Further, the developed canal is filled with the bio-compatible filling materials. The procedure of removing the substrate from infected teeth and filling with bio-material is called as root canal obturation. Thus obturation helps in creating fluid tight seal at canal wall and filling material to avoid the percolation of the oral fluids[1].

Mircoleakage is defined as percolation of debris, oral fluids, micro-organisms or ions through the interface gap between restorative (filling material) and the wall of the tooth[2]. The various clinical studies mentioned the micro leakage is the vital cause for failure of the root canal treatment[3]. However, the aim of any root canal treatment is complete filling of the cavity in three dimensions[4]. There are various parameters which are responsible for creating the leakages in the obturated canal using any obturation technique. As far as our concern and considering the outline of this investigation the shrinkage of the gutta-percha during solidification is major reason. For this reason there is need to fabricate the test rig which can quantify the micro leakage in the obturated root canal.

The various quality assessment techniques had been developed viz. dye penetration test, scanning electron microscope, micro computed tomography, cone beam computed tomography, radiography, bacterial micro leakage, computational fluid dynamics etc. The dye penetration test is less costly to perform but the results and conclusion of the test found challengeable. Scanning electron microscope is best non-destructive technique but results are limited to surface information[5]. The micro computed tomography gives the three dimensional visualization and is qualitative technique[6]. Radiographic information is limited to the white lines[7]. The fluid filtration and bacterial micro leakage gives the quantification of the micro leakage. Computational fluid dynamics is a numerical tool which helps in solving the fluid dynamics equations by suitable method which can capture the essential physics of fluids.

This study fabricated the fluid filtration system to measure the micro leakage in obturated root canal using Warm vertical condensation, Cold lateral condensation and Thermafil. The fabricated fluid filtration system consist of oxygen cylinder, pressurized buffer system, micro pipette, three way control faucet, syringe and tooth test samples as constructional components. The measurement system consist of DSLR camera and Auto CAD software to record the micro leakage.

Literature Review and consultation with Endodontic experts

Literature Review

The gutta-percha is commonly used obturation material along with the sealer to create the fluid tight seal in root canal cavity. Amir moinzadeh et al[8] used lateral compaction of gutta-percha technique coupled with calcium silicate sealer. However he reported the voids and poor root fillings of cavity. The void % calculation was based on 3D data with 10 micro meter voxel size. Daniele angerame et al[9] used the micro computed tomography study and void percentage and root filling related to entire canal volume was calculated. He assessed the quality of canal filling based on single point technique and continuous wave of condensation technique. Edith siu shan et al[10] conducted the density based assessment to compare the quality of root canal fillings obturated with three different techniques viz. cold lateral compaction, ultrasonic lateral compaction and warm vertical compaction techniques. Warm vertical compaction and ultrasonic lateral compaction gave denser filling than cold lateral compaction technique. Mothanna K. et al[11] studied quality of 259 gutta-percha filling samples of various locations using dental X-ray unit. On basis of radiographic evaluation they compared the performance of the undergraduate students at Taibah University KSA. Ugur inan et al[12] compared three obturation techniques using electrochemical evaluation and linear dye penetration evaluation techniques. Apical sealing ability of System B, Thermafil and cold lateral condensation were compared. It was found that highest leakage reported by cold lateral condensed sample and lowest leakage reported by Thermafil and in between for System B. Saeed moradi et al[3] conducted study to compare there is no significant difference between Bacterial leakage and fluid filtration techniques. But bacterial leakage technique should be replaced with fluid filtration technique since bacterial leakage technique requires more time, procedure is more complex and requires skilled micro-biologist.

Christos boutsioukis et al. conducted computational fluid dynamics analysis to evaluate the effect of needle tip on the irrigant flow inside the canal in final stage of preparation[13]. Computational fluid dynamics proved to be powerful tool for investigation of the fluid flow behavior with its best mathematical modeling and simulation features[14,15]. It helps to simulate the various parameters with actual experimental conditions which are difficulty to perform. In some studies computational fluid dynamic model used to assess the irrigant flow behavior in root canal during preparation[16]. While in some cases the same is validated using experimentation by using high speed imaging data tracking[17].

Consultation with Expert of Endodontic & Conservative Dentistry

We had hours of discussion with ample of experts who are working in the Endodontic field more than decade. The purpose of consultation was to receive the various problems in the obturated root canal related to micro-leakage. We had received the consultation report summary and accordingly formulated our problems statement, scope to be worked upon etc.

The Dentists which are selected for carrying the consultation are relying on the various qualitative techniques viz. μ-CT, Cone Beam Computed tomography, CT Scans, Scanning electron microscope, Radiography etc. for assessment of the quality of the obturation. On the other hand the ability of the qualitative is dependent of the ability device for imaging and resolution. Still one of the most identified drawback through the consultation with Dentist is the qualitative techniques are not having the features to measure the micro leakage.

There are various parameters which are responsible for creating the leakages in the obturated canal using any obturation technique. As far as our concern and considering the outline of this investigation the shrinkage of the gutta-percha during solidification is major reason. For this reason there is need to fabricate the test rig which can quantify the micro leakage in the obturated root canal.

MATERIALS AND METHOD

Micro-leakage is defined as seepage of fluids, debris, micro organisms or ions along the interface between a restorative or a filling material and the wall of the tooth. Mechanical sealing provides the quantification of leakage in terms of mechanical sealing. The fluid filtration system has been fabricated to predict the micro leakage is described in the following section.

Fluid Filtration System

The fluid filtration system has been fabricated to measure the micro leakage present into the prepared tooth samples. The tooth samples

Table 1. Consultation with Dentist of endodontics report summary

Questions asked to Dentist	Response	Author's remark
The obturator device currently in use is based on which technique?	Warm Vertical condensation	The warm vertical condensation technique is widely accepted and can be recommended to new researcher in their research.
Does the obturation device currently in your practice is automated?	No	Manual pouring of the gutta-percha and compacting it using compactor needle may introduce the idle time by which the poured gutta-percha may get solidified already.
How do you assess the quality of the root canal obturated by you?	Various qualitative technique are being used by practitioner viz. μ-CT, CBCT, radiography etc.	The device which can quantify the root canal obturation is need of the dentist.
Are you comfortable with the qualitative techniques?	No	The assessment of quality relies imaging and resolution of the technique.
Which are various defects of obturation?	Shrinkage defect: the softened gutta-percha gets shrink during solidification.	Shrinkage of the gutta-percha creates space between filled gutta-percha and root canal wall.
Does the qualitative assessment techniques gives the micro leakage during life of obturated canal?	No	There is need of the development of the system which will help in the quantification of the micro leakage in obturated canals during their life span.

had prepared with warm vertical condensation techniques. System contains the micropipette of 0.1 cc which enables to note down the bubble displacement in micropipette with DSLR camera and AutoCAD software.

Oxygen cylinder

Oxygen cylinder applies the pressure on the fluid for displacement of the bubble. Variable pressures can be applied on fluid by adjusting the pressure with pressure adjusting device. A latex tube connects the oxygen cylinder and pressurized buffer system.

Pressurized buffer system

Pressurized buffer system contains inlet and outlet tubes on its cap. Inlet tube is made up of latex plastic and outlet tube is made up of glass. Inlet tube allows entry of oxygen from oxygen cylinder into pressurized buffer system. Inlet tube has been kept above the fluid level. Outlet tube discharges fluid of the pressurized buffer system. Outlet tube is entirely dipped into the fluid of pressurized buffer system.

Micropipette

The outlet tube of pressurized buffer system is connected to micropipette of 0.1 cc. Micropipette is fixed on the board structure horizontally for avoiding disturbances. The micropipette is then connected to bilateral control faucet.

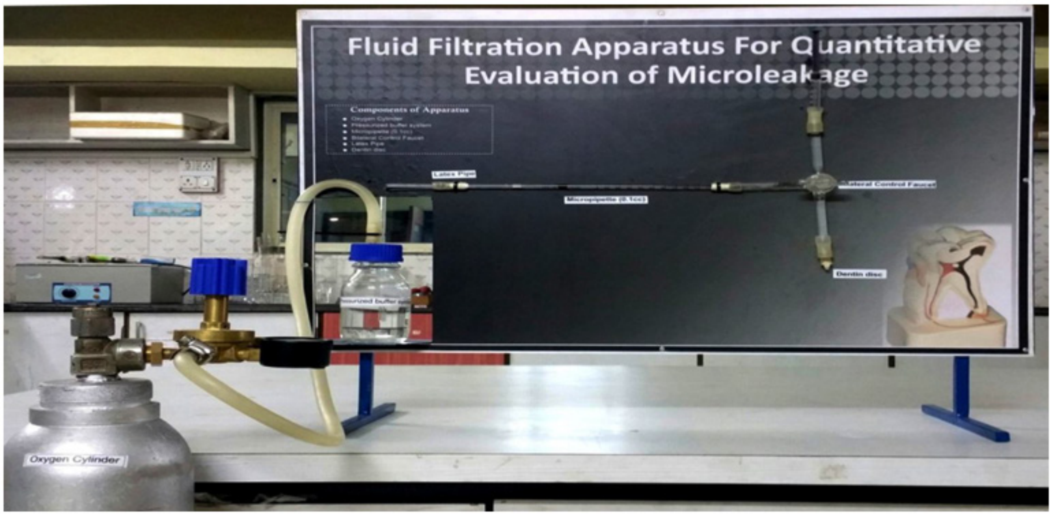

Fig.1. Fluid filtration system for micro leakage measurement

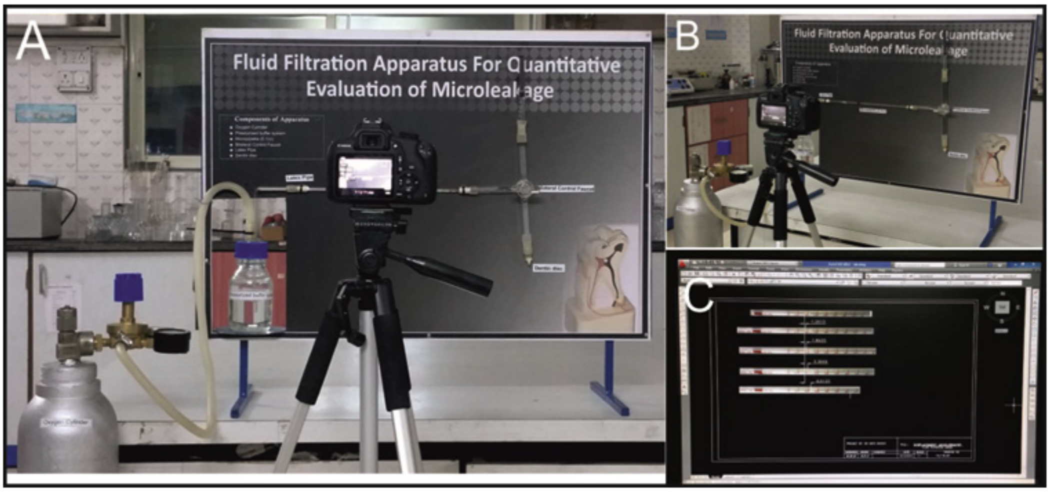

Fig.2. Measurement of bubble displacement using on Auto CAD Software

Bilateral control faucet

Bilateral control faucet receives the fluid from micropipette. There are two other outlet openings are available, upper and lower. Upper opening is connected to syringe. Syringe helps to create air bubble in micropipette. Lower opening is connected to tooth sample.

Tooth sample

Tooth sample is prepared with warm vertical condensation of gutta-percha techniques. Certain porosity in gutta-percha filling or gap present at interface of gutta-percha filling and cavity can be detected.

Measurement system

Measurement system contains DSLR camera and AutoCAD software. With help of DSLR camera entire range of micropipette reading is covered. To avoid the parallax error in noting the reading, DSLR is kept as close as to micropipette. The components of the fluid filtration systems are shown in Fig.1.

Sample Preparation

Control group of samples

Positive control group sample: Samples undergone canal preparation but not obturated and Negative control group sample: Samples undergone canal preparation and sealed with cement

Category I: Warm vertical condensation

Pro-taper master cone gutta-percha available in 6% taper and precisely matched to shapes of finishing files were used. The DENTSPLY plugger were used for warm gutta-percha vertical condensation techniques. There were four plugger in the set and they had working diameter range from 0.5 mm, 0.7 mm, 0.9 mm and largest plugger was sized 1.3 mm. Additionally plugger had reference lines at 5 mm enabling the depth of plugger in the root canal system all the time. Pro taper paper point were available from F1 to F5 corresponds to finishing. Kerr pulp canal sealer was used with warm gutta-percha vertical condensation extended the working time. Kerr pulp canal sealer support certain advantages viz. un-matured flow, viscosity can be varied with case, essentially non-resorbable, it sets desirable in presence of heat, and blocks pains. Sealer was mixed with zinc oxide powder

Table 2. Micro leakage reading for obturated tooth sample using warm vertical condensation, cold lateral condensation and Thermafil

Sample No.	Category I: Warm vertical condensation		Category II: Cold lateral condensation		Category III: Thermafil	
	mm/hr	μ L/min	mm/hr	μ L/min	mm/hr	μ L/min
1	5	0.06	26	0.34	9	0.11
2	5	0.06	27	0.35	7	0.09
3	4	0.04	28	0.36	11	0.14
4	5	0.06	26	0.34	9	0.11
5	2	0.02	30	0.39	7	0.09
6	2	0.02	27	0.35	9	0.11
7	3	0.03	26	0.34	7	0.09
8	2	0.02	28	0.36	9	0.11
9	3	0.03	28	0.36	7	0.09
10	3	0.03	27	0.35	8	0.10
11	3	0.03	26	0.34	9	0.11
12	4	0.04	30	0.39	8	0.10
14	3	0.03	27	0.35	8	0.10
15	3	0.03	27	0.35	8	0.10

Table 3. Mean and standard deviations of sample categories selected for study

Category	I	II	III
Number of samples	15	15	15
Mean of samples	0.03	0.33	0.10
Standard deviation	0.0021	0.0033	0.0023

and poured down into the canal. The prepared master cone was buried into the sealant liberally. Kerr 5004 Touch N Heat is heat transfer unit used and is best choice for warm gutta-percha vertical condensation. The standard working length of 3.5 to 4.2 mm was used for obturation.

Category II: Cold lateral condensation

The sample was obturated using warm vertical condensation technique. The epoxy sealant was used as per manufactures catalogue and instructions. For entire length of canal paper point sealer was applied. For later reach of the master cone gutta-percha, finger spreader was used in between canal wall and master cone. For 1.5 mm working length spreader was inserted. The cavities created by the spreader were recovered by using condensation of auxiliary gutta-percha points. The procedure is performed repeatedly till more than 2.5-3 mm gutta-percha inserted into the canal. The extra gutta-percha then removed using hot source plastic instrument. The standard working length of 3.5 to 4.2 mm was used for obturation.

Category III: Thermafil

Thermafil was used to obturate 15 samples considered for study. After preparation of the canal using nickel-titanium file of size 30. The carrier forced by twisting and rotating to reach full length. The adjustment of rubber marker was done as per working length. The sealant along with paper point was used. The obturator kept into Therma oven then dipped into canal as per making of the working length. After radiographic verification, the carrier shaft is severed with inverted cone bur at the canal orifice. The gutta-percha then vertically condensed by condenser lubricated with Vaseline. The standard working length of 3.5 to 4.2 mm was used for obturation.

Experimental procedure

Firstly, Category I: 15 No's of samples obturated using warm vertical condensation were assessed using fluid filtration system. Firstly intact disc was connected to three way control faucet. The control faucet adjusted such that it restricts connection to tooth sample and only syringe and micropipette remain connected. Syringe created the bubble equal to diameter of micropipette. After creating the bubble in micropipette control faucet was adjusted such that syringe was disconnected so that control faucet connected the micropipette to tooth sample. Later on oxygen was released from the oxygen cylinder with help of pressure adjusting device and bubble movement in the micropipette was noted down with the help of DSLR camera. The DSLR recorded the bubble movement after specified time interval. DSLR images were taken to AutoCAD software for measurement of bubble displacement.

The above procedure is repeated for remaining two categories viz. Category II: 15 No's of samples obturated using cold lateral condensation and Category III: 15 No's of samples obturated using Thermafil.

RESULTS AND DISCUSSION

The micro leakage reading are shown in Table 2 and tabulated values showed that Category II: 15 No's of samples obturated using cold lateral condensation, showed highest micro leakage value highest micro leakage followed by Category III: 15 No's of samples obturated using Thermafil and Category I: 15 No's of samples obturated using warm vertical condensation. Category III shown moderate leakage value.

One way ANNOVA test was used to estimate the P-value and 5% confidence level. Statistically mean value in Category II (samples obturated using cold lateral condensation, 0.33±0.0033) is higher than Category I (samples obturated using warm vertical condensation) (0.03±0.0021) and Category III (samples obturated using Thermafil) (0.10±0.0023). The mean and standard deviations are shown in Table 3.

The considerable micro leakage indicates incomplete filling of obturated cavity, shrinkage and improper compaction of filling materials. Comparatively, among the samples there is no significance difference in micro leakage found the reason can be standard treatment procedure for cleaning and shaping the root canal cavity were being used, followed by obturation with warm vertical condensation of gutta-percha. The fluid filtration methods having number of advantages over others as it is non-destructive technique, avoids operator bias, gives more accuracy since small volume can be recorded in micro-liter per minute.

Fluid filtration system provides a novel approach for perfect quantification of the micro leakage evaluation. Till date there are number of the qualitative analysis methods made available for micro leakage studies which lacks scientific significance. The various gases can be used for the fluid filtration system viz. oxygen, helium and nitrogen etc[22]. The pressure applied by the gas in the system may be kept constant and depends upon the material to be tested. The pressure range in which studies were conducted is 3 Psi to 121590 Psi[22, 23]. There is need of alternative analytical or numerical method which can validate the results of fluid filtration system. Standardization of fluid filtration system can be done for repeatability and accuracy of micro leakage reading. For clinical acceptance of this study in vivo approach should be used. However the proposed fluid filtration system does not validated with clinical measurement. We had taken the extracted teeth for measurement of the micro leakage. On the other hand the this fluid filtration system can be used for any assessment of micro leakage in any 'X' bio material and obturation technique.

CONCLUSION

1. The study indicated that micro leakage evaluation using the fabricated fluid filtration system is most reliable quantitative method which can be used for micro leakage assessment samples obturated with any obturation technique.
2. On the basis of comparison of micro leakage assessment of three obturation techniques it is found that warm vertical condensed sample having least leakage over the Thermafil and Cold lateral condensation.
3. The reason for difference in mean values of leakage measured for three obturation techniques can be shrinkage of gutta-percha during solidification, variations in shaping the canal because of which the gap between canal wall and obturation materials gets created.
4. The micro leakage of obturated sample can be reduced by providing shrinkage allowance, by pouring the excess volume of molten gutta-percha during solidification phase to ensure complete filling of cavity. For accurate solidification process to happen heating and compaction of gutta-percha should be automated during solidification process.

ACKNOWLEDGEMENTS

Author acknowledges the support and guidance received from Dr. Asiya Shaikh of M. A. Rangoonwala College of Dental Sciences and Research Centre Pune, India for helping to complete this research.

REFERENCES

1. Ratnakar R. Ghorpade.: Deformation studies of endodontic obturator tip using FEM approach. *International Journal of Engineering Inventions*, **1**(4): 19-26 (2012).
2. Cifticia A.: Coronal micro leakage of four endodontic temporary restorative materials: an in vitro study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endo* **108**: 067-070 (2009).
3. Saeed Moradi .: Comparison of fluid filtration and bacterial leakage techniques for evaluation of micro-leakage techniques in endodontics. *Dent Res J* **12**(2): 109-114 (2013).
4. Herbert Schilder.: Filling of root canals in three dimensions. *Journal of Endodontics* **32**(4): 281-290 (2006).
5. Jisele Nevares.: Efficacy of pro-taper next compared with reciproc in removing obturation material from severely curved root canals a micro-computed tomography study. *Basic Research Technology* **42**: 803-808 (2016).
6. John Whitworth.: Methods of filling root canals: principles and practices. *Endodontics* **12**: 2-24 (2005).
7. Girhotra R.: Scanning electron microscopic evaluation of sealing ability of root canals with various obturation techniques. *Endodontology* **11**: 15-20 (1999).
8. Amir T. Moinzadeh.: Porosity distribution in root canals filled with gutta-percha and calcium silicate cement. *Dental Materials* **52**: 1-10 (2015).
9. Daniele A.: Resistance of endodontically treated roots restored with different fibre post systems with or without post post space preparation: in vitro analysis and SEM investigation. *Endodonzia* **30**: 111-119 (2014).
10. Edith S.: Quality of root canal fillings using three gutta-percha techniques. *Restorative Dentistry and Endodontics* **51**: 236-247 (2015).
11. Mothanna K.: Technical quality assessment of root canal treatment performed by pre-clinical dental students at Taibah university. *Material*

Sciences **41**: 27-32 (2016).

12. Ugur I.: Leakage evaluation of three different root canal obturation techniques using electrochemical evaluation and dye penetration evaluation methods. *Aust Endod J,* **33**: 18-32 (2007).
13. Christos B.: Evaluation of Irrigant Flow in the Root Canal Using Different Needle Types by an Unsteady Computational Fluid Dynamics Model. *Journal of Endodontics* **10**: 1-7 (2010).
14. Tilton JN. Fluid and particle dynamics. In: Perry RH, Green DW,Maloney JO, eds. Perry's Chemical Engineer's Handbook. 7th ed. New York, NY: McGraw-Hill; 1999: 1–50.
15. Arvant A.: A validated computational fluid dynamics model to estimate hemolysis in a rotary blood pump. *Artif Org* **29**: 531-540 (2005).
16. Boutsioukis C.: Irrigant flow within a prepared root canal using different flow rates: a computational fluid dynamics study. *Int Endod J* **42**: 144-155 (2009).
17. Boutsioukis C.: Irrigant flow in the root canal: experimental validation of an unsteady computational fluid dynamics model using high speed imaging. *Int Endod J* (in press).
18. Javidi M.: Assembling of the fluid fitration system for quantitative evaluation of microleakage in dental materials. *J Endod Iran* 3: 68-72 (2008).
19. Gustavo De.: A new dimension in old leakage methods. *Int Endod J,* **41**: 720-733 (2008)
20. Conte G.: Fluid filtration and dye leakage testing of Resilon /Epiphany and Gutta Percha /pulp canal sealer root canal fillings. *Open J Stomatology* **3**: 14-21 (2013).
21. Prati C.: Permeability and microleakage of class II resin composite restorations. *J Dent* **22**: 49-56 (1994).
22. Camps J.: Influence of concentration of application time of maleic acid on dentin permeability. *Dent Mater* **11**: 117-81 (1995).
23. Wimonchit S.: Comparison of techniques for assessment of coronal dye leakage. *J Endododontics* **28**: 1-4 (2002).