Original Article

Received : 17-09-14
Review completed : 29-10-14
Accepted : 03-11-14

COMPARATIVE EVALUATION OF APICAL LEAKAGE AFTER POST SPACE PREPARATION IN ROOT CANALS OBTURATED USING THREE RESIN-BASED ROOT CANAL SEALERS: AN *IN-VITRO* STUDY

Chhavi Arora, * Manju Kumari, ** Sonali Taneja ***

* MDS, Private Practitioner, Ghaziabad, Uttar Pradesh, India
** Professor, Department of Conservative Dentistry and Endodontics, ITS Centre for Dental Studies and Research, Ghaziabad, Uttar Pradesh, India
*** Professor & Head, Department of Conservative Dentistry and Endodontics, ITS Centre for Dental Studies and Research, Ghaziabad, Uttar Pradesh, India

ABSTRACT

Aim: The aim of this in vitro study was to evaluate and compare the apical seal of three resin-based sealers after post space preparation using glucose penetration method. **Methods:** Forty single rooted premolars decoronated at 16 mm were prepared using crown down technique. They were divided into three experimental groups of ten samples each, obturated with EndoREZ/ EndoREZ point, RealSeal/ Resilon points and MetaSEAL/ gutta-percha and two control groups (positive and negative) of five samples each. All the specimens were stored at 37 °C and 100% relative humidity in incubator for 24 hours. Post space preparation was carried out with Peeso reamer #1 to #3 leaving 5 mm of material. The apical leakage was tested at different time intervals using glucose leakage model. Glucose leakage values were measured using a spectrophotometer and statistically analysed. **Results:** The positive control group showed maximum apical leakage whereas, in the negative control group, no apical leakage was detected at all time periods. At all time periods, the mean apical leakage value was higher in EndoREZ group followed by RealSeal and MetaSEAL and difference between them was statistically significant ($p<0.05$). **Conclusion:** All the experimental groups showed increased degree of apical leakage from first day to end and among all EndoREZ showed the most and RealSeal showed the least apical leakage.

KEYWORDS: Apical leakage; EndoREZ, glucose penetration model; MetaSEAL, RealSeal; resin based sealers

INTRODUCTION

During mechanical preparation of the post space, the root canal filling material may be dislodged creating voids in the obturation,[1] and the filling material may be twisted or vibrated. This procedure may affect the quality of apical seal. Several factors can affect the integrity of apical seal while post space is prepared, such as length of gutta-percha to maintain the apical seal,[2] time of removal of filling material,[3] and method of gutta-percha removal.[4] Also, the type of sealer and its bonding with root dentin as well as core material will affect the apical seal integrity. Ideally, the root canal sealer should be capable of bonding to the root canal walls and to gutta-percha, thus effectively preventing microleakage.[5] The relatively recent introduction of methacrylate-based resin endodontic sealers has been a major step towards achieving bond to both the canal wall and the core material. These root canal sealers have been aggressively promoted with the highly desirable property of creating monoblocks within the root canal space.[6] **EndoREZ** (second generation) a dual-cure radiopaque resin-based sealer has been introduced in the market and its active ingredient is urethane dimethacrylate (UDMA).[7] According to the manufacturer, EndoREZ is biocompatible and has satisfactory sealing properties, hydrophilic characteristics and an easy delivery system. **RealSeal** sealer is a third generation methacrylate resin- based sealer which is a dual curable dentin resin composite sealer[8] and might be used in conjunction with **Resilon** points. It has

Table 1: Intergroup comparison of mean apical leakage values at different time periods

Groups	Glucose concentration, mmol/L (mean ± SD)				
	Day 1	Day 7	Day 14	Day 21	Day 28
Group 1 EndoREZ	0.412±0.012$^{(2,3)}$	2.133±0.105$^{(2,3)}$	5.155±0.140$^{(2,3)}$	7.093±0.141$^{(2,3)}$	9.93±0.10$^{(2,3)}$
Group 2 MetaSEAL	0.218±0.015$^{(1,3)}$	0.609±0.015$^{(1,3)}$	3.184±0.161$^{(1,3)}$	5.101±0.131$^{(1,3)}$	8.112±0.125$^{(1,3)}$
Group 3 RealSeal	0.315±0.014$^{(1,2)}$	1.232±0.122$^{(1,2)}$	4.177±0.160$^{(1,2)}$	6.128±0.108$^{(1,2)}$	9.087±0.144$^{(1,2)}$

been claimed to create a monoblock, meaning the creation of a solid, bonded, continuous material from one dentin wall of the canal to the other with a superior seal.[8] A self-adhesive, dual curable methacrylate resin-based sealer MetaSEAL (fourth generation) has recently been introduced commercially.[9] The sealer purportedly bonds to thermoplastic root-filling materials as well as radicular dentin via the creation of hybrid layers in both substrates. Till date, no study has compared the sealing ability of these three methacrylate based sealers together after post space preparation using glucose penetration model.

MATERIALS AND METHODS

Forty recently extracted mandibular premolars with single canal were used in the study. Teeth having cracks, extensive carious lesions, immature apices, and resorptions were excluded. The tooth was decoronated by using a diamond disk under water cooling, leaving 16-mm-long root. To establish the root canal length, a size 15 K-file (DENTSPLY-Maillefer) was inserted into the canal until the tip was just visible at the apical foramen. The working length for root canal preparation was determined by subtracting 1 mm from this length. The root canals were prepared using Protaper rotary instruments (DENTSPLY-Maillefer) from S1 till F3 sequentially, to get the desired apical preparation of # 30. During preparation and between each instrument, 1ml of 5.25 % NaOCl was used as an irrigant. After the completion of canal preparation, all specimens received a flush of 5 ml of 5.25 % NaOCl and 5 ml of 17% EDTA for 1 min to remove the smear layer followed by final rinse with 5ml of distilled water. Glyde FILE PREP was used during instrumentation for lubrication. The root canal was dried with paper points. The master point of apical size 30 and 6% taper was coated with mixed sealer and fitted into the canal. Lateral compaction was done with the accessory points of size 25 and 2% taper. The roots were randomly distributed into 4 experimental (n=10) and 2 control groups (n =5). Group 1 (n=10): Obturation was done with EndoREZ sealer/ EndoREZ points (Ultradent Products Inc., lot no: B783J, South Jordan, UT, USA). Group 2 (n=10): Obturation was done with RealSeal/ Resilon (Sybron Dental Specialties, lot no: 13B21, Orange, CA, USA). Group 3 (n=10): Obturation was done with MetaSEAL/ gutta-percha (Parkell Inc., lot no: S160, Farmington, NY, USA). All the sealers were mixed according to manufacturer's instructions. Positive Control (n=5): Obturation was done with EndoREZ points only. Negative Control (n=5): Obturation was done with EndoREZ sealer/ EndoREZ points and the entire specimen was coated with sticky wax and nail polish including root canal orifices and apical foramina. The coronal surface of the obturation in the chamber was light-cured for 40 seconds to create an immediate coronal seal. After obturation, excess gutta-percha was removed with a hot burnisher. All experimental and control teeth were stored at 37^{o}C and 100% humidity in the incubator for 24 hours to allow the sealers to set. After the setting of the sealers, the post space preparation was carried out using Peeso Reamers with the sequence #1 upto #3 leaving 5 mm of obturating material apically.

Apical Leakage Measurement

Apical leakage was evaluated using the glucose leakage model as described by Xu *et al.*[10] The concentration of leaked glucose (mmol/L) was measured at 1, 7, 14, 21 and 28 days with a glucose kit in spectrophotometer at 340 nm wavelength. Mean values and standard deviations of apical leakage were calculated for each group of specimens and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS). Statistical analysis was performed with the ANOVA and Post-Hoc (Tukey HSD) at significance level of $P < 0.05$.

RESULTS

Table 1 shows the intergroup comparison of mean apical leakage values at different time periods. The positive control group showed high values of glucose leakage from the first day and it increased rapidly over time. In the negative control group, no glucose was detected in all apical reservoirs throughout the experiment. This indicated that the seal of the system was effective and reliable. There was a tendency of increase in leakage in all experimental groups from the first day to the end of experimental period. At all time periods, the mean apical leakage value was found to be higher in EndoREZ/EndoREZ points followed by RealSeal/Resilon and MetaSEAL/gutta-percha. Statistically significant difference was found among all experimental groups at all time periods ($P<.05$).

DISCUSSION

In view of the extremely high C-factor encountered in long, narrow root canals,[11] this study was done to find whether the core material and methacrylate based sealer bond is capable of resisting polymerization shrinkage stresses that develop during the setting of the resin sealer as well as the stresses generated during post space preparation to permit the realization of the goal of creating a monoblock in the root canal system. In the present study, all experimental materials tested showed some degree of apical leakage at all time periods. This could be due to the reduced effectiveness of smear layer removal,[12] prevention of deeper penetration of irrigating solutions & root canal sealers and mechanically unfavourable bonding leading to increase in shrinkage stresses[13] at the root apex. Also, the resin sealers are not able to flow because of the constrained space, which results in accumulation of stresses that develop within the polymerizing resin. All these factors along with the rotational forces created during post space preparation might have caused movement of the gutta-percha, thus breaking the adhesive bond at the sealer interface leading to leakage in all groups. The lower leakage in RealSeal than MetaSEAL could be due to more aggressive nature of the sealer. The pH of RealSeal is 2.5 and has shown to create a thin layer of partially demineralized dentin even underneath the smear layer.[14] A partially demineralized zone is necessary for hybrid layer formation. Kim and others in their study could identify hybrid layer formation on dentin surface of either sealer i.e. RealSeal and RealSeal SE.[14] They found that dissolution of the apatite crystallites was more complete for RealSeal as a result of combine etching effects of EDTA and the self-etching primer when compared with less aggressive self-etching adhesive (RealSeal SE). Another reason for lower leakage in RealSeal group could be due to better penetration because of the application of SEPs.[15,16]

In comparison to RealSeal, MetaSEAL has a high pH of 3.8 and is not aggressive enough to partially demineralize dentin, even after irrigating with EDTA for smear layer removal.[17] Also, the buffering capacity of apatites within smear layer could have further reduced the sealer's self-etching potential. Mild self-etching adhesives with pH values between 2 and 3, partially demineralize dentin to a depth of 0.2-0.5 µm.[18] According to Kim et al.[14] instrumented root canal systems contain areas that can be inaccessible to canal irrigating solutions such as EDTA. This can result in retention of debris and smear layers especially along the apical third of the canal walls, isthmi, fins, and accessory root canals. It is in these secluded regions of the root canal system that the etching of radicular dentin through the thick smear layer is particularly critical due to the absence of the demineralizing effects of calcium chelating agent. An absence of seal in these crucial areas will invariably lead to higher microleakage. Our results demonstrate this concept of the poor etching capacity of MetaSEAL, which led to the increased microleakage in contrast to RealSeal. Thus, it is unlikely that MetaSEAL with a measured pH of 3.8 can etch beyond clinically relevant smear layers to create micromechanical retention in intact dentin. In our study the higher leakage shown by EndoREZ than RealSeal could be due to lack of self-etching of the sealer to dentinal walls.[19] It is hydrophilic in nature and requires removal of canal wall smear layer in order to enhance sealer penetration in dentinal tubules. The effectiveness of smear layer techniques is reduced closer to the apex.[12] Therefore, there is a possibility of incomplete removal of smear layer after a final flush with NaOCl and EDTA and this could have affected the resin sealer penetration causing more leakage. In various studies, EndoREZ have shown higher apical leakage.[20,21]

Unfavourable leakage values for EndoREZ were also noted in other studies.[22,23] In the present study RealSeal sealer was used with Resilon polycaprolactone polymer core which contains a blend of dimethacrylates that bonds with the methacrylate-based sealer,[24] which in turn bonds with the root dentin, forming a monoblock that may improve the seal and strengthen the endodontically treated tooth.[25] This could have resulted in the better performance of RealSeal than EndoREZ in our study. However, Muñoz and others[26] in their study showed that there was no significant difference in microleakage of teeth filled with RealSeal/Resilon and RealSeal/gutta-percha after post space preparation by mechanical technique. In comparison to RealSeal/ Resilon group, more leakage in EndoREZ/EndoREZ points could be due to the debonding of resin sealer from resin coated gutta-percha. This is due to lack of oxygen inhibition layer which is necessary for optimal coupling of methacrylate-based resins.[27,28] The removal of oxygen inhibition layer from the surface of resin-coated gutta-percha cones during packaging has been hypothesized for their weak adhesion to the methacrylate resin-based root canal sealer.[27] Till date no studies are available comparing leakage of EndoREZ and RealSeal, however, we have studies comparing EndoREZ and Epiphany (self-etch primer sealer). Epiphany is a third generation self-etch primer sealer like RealSeal. The RealSeal system is assumed to be chemically identical with Epiphany/ Resilon system.[29] Some studies found no statistically significant difference in leakage values between EndoREZ and Epiphany (self-etch sealer).[30,31] However, in other studies[32,33] EndoREZ leaked significantly more than Epiphany/Resilon groups. In comparison to EndoREZ, MetaSEAL have self-etching potential. It also consist of 4-META monomer in its composition, which has a hydrophilic radical that bonds to dentine and a hydrophobic radical that bond to the solid filling material.[34] According to Van Landuyl and others,[35] the two carboxylic groups attached to the aromatic group produce acidification and demineralization of the surface and also enhance wetting factors that are essential to promote adhesion of the material to the surface. This could have led to lower leakage in MetaSEAL.

CONCLUSION

Under the conditions of this in vitro study it can be concluded that: a) All the experimental groups showed some degree of apical leakage at all time periods and there was increase in the apical leakage values from first day to end of experimental period; b) At all time periods, the mean apical leakage value was found to be higher in EndoREZ/EndoREZ points followed by RealSeal/Resilon and MetaSEAL/gutta-percha and difference between them was statistically significant. However, further laboratory studies and clinical trials are needed to evaluate the long-term efficacy of these methacrylate based sealer.

CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of funding and there is no conflict of interest among all authors.

BIBLIOGRAPHY

1. Dalat DM, Spangberg LSW. Effect of post space preparation on the apical seal of teeth obturated with plastic Thermafil obturators. Oral Surg Oral Med Oral Pathol. 1993;76:760-5.
2. Mattison GD, Fraunhofer J. Electrochemical microleakage study of endodontic sealer cements. Oral Surg Oral Med Oral Pathol. 1983;55:402-7.
3. Bourgeois R, Lemon RL. Dowel space preparation and apical leakage J Endod. 1981;7:66-9.
4. Haddix JE, Mattison GD, Shulman CA, Pink FE. Post space preparation techniques and their effect on the apical seal. J Prosthet Dent. 1990;64:515-9.
5. Zmener O, Pameijer CH, Macri E. Evaluation of the Apical Seal in Root Canals Prepared with a New Rotary System and Obturated with a Methacrylate Based Endodontic Sealer: An In Vitro Study. J Endod. 2005;31:392-395.
6. Tay FR, Pashley DH. Monoblocks in root canals: a hypothetical or a tangible goal. J Endod. 2007;33:391-8.
7. Dultra F, Barroso JM, Carrasco LD, Capelli A, Guerisoli DMZ, Pecora JD. Evaluation of apical microleakage of teeth sealed with four different root canal sealers. J Appl Oral Sci. 2006;14:341-345.

8. Shipper G, Orstavik D, Teixeira FB, Trope M. An evaluation of microbial leakage in roots filled with a thermoplastic synthetic polymer-based root canal filling material (Resilon). J Endod. 2004;30:342-7.
9. Lawson MS, Loushine B, Mai S, Weller RN, Pashley DH, Tay FR, Loushine RJ. Resistance of a 4-META-containing, methacrylate-based sealer to dislocation in root canal. J Endod. 2008;34:833-7.
10. Xu Q, Fan B, Fan MW, Cheung GS, Hu HL. A new quantitative method using glucose for analysis of endodontic leakage. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;99:107-111.
11. Tay FR, Loushine RJ, Lambrechts P, Weller RN, Pashley DH. Geometric factors affecting dentin bonding in root canals: a theoretical modeling approach. J Endod. 2005;31:584-9.
12. Mamootil K, Messer HH. Penetration of dentinal tubules by endodontic sealer cements in extracted teeth and in vivo. Int Endod J. 2007;40:873-81.
13. Bouillaguet S, Troesch S, Wataha JC, Krejci I, Meyer JM, Pashley DH. Microtensile bond strength between adhesive cements and root canal dentin. Dent Mater 2003;19:199-205.
14. Kim YK, Mai S, Haycock JR, Loushine RJ, Pashley DH, Franklin RT. The self-etching potential of RealSeal versus RealSeal SE. J Endod 2005;35:1264-9.
15. Shipper G, Teixeira FB, Arnold RR, Trope M. Periapical inflammation after coronal microbial inoculation of dog roots filled with gutta-percha or resilon. J Endod 2005;31: 91-6.
16. Gharib SR, Tordik PA, Imamura GM, Baginski TA, Goodell GG. A confocal laser scanning microscope investigation of the epiphany obturation system. J Endod 2007;33:957-61.
17. Mai S, Kim YK, Hiraishi N, Ling J, Pashley DH, Tay FR. Evaluation of the True Self-etching Potential of a Fourth Generation Self-adhesive Methacrylate Resin-based Sealer. J Endod 2009;35:870-4.
18. Keshima S, Reis A, Uceda-Gomez N. Effect of smear layer thickness and pH of self-etching adhesive systems on the bond strength and gap formation to dentin. J Adhes Dent 2005;7:117-26.
19. Babb BR, Loushine RJ, Bryan TE, Ames JM, Causey MS, Kim J, Kim KY, Weller RN, Pashley DH, Tay FR. Bonding of Self-adhesive (Self-etching) Root Canal Sealers to Radicular Dentin. J Endod. 2009;35:578-82.
20. Sevimay S, Kalayci A. Evaluation of apical sealing ability and adaptation to dentine of two resin-based sealers. J Oral Rehab 2005;32:105-110.
21. Oruçoglu H, Sengun A, Yilmaz N. Apical Leakage of Resin Based Root Canal Sealers with a New Computerized Fluid Filtration Meter. J Endod. 2005;31:886-90.
22. da Silva Neto UX, de Moraes IG, Westphalen VP, Menezes R, Carneiro E, Fariniuk LF. Leakage of 4 resin-based root-canal sealers used with a single-cone technique. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104:e53-7.
23. Gernhardt CR, Kruger T, Bekes K, Schaller HG. Apical sealing ability of 2 epoxy resin-based sealers used with root canal obturation techniques based on warm gutta-percha compared to cold lateral condensation. Quintessence Int. 2007;38:229-34.
24. Jia W, Alpert B, inventors; Pentron Clinical Technologies, LLC (Wallingford, CT, US), assignee. Root canal filling material.US patent application. 20030113686. June 19, 2003.
25. Teixeira FB, Teixeira EC, Thompson JY, Trope M. Fracture resistance of roots endodontically treated with a new resin filling material. J Am Dent Assoc. 2004;135:646–52.
26. Munoz HR, Saravia-Lemus GA, Florian WE, Lainfiesta JF. Microbial Leakage of Enterococcus faecalis After Post Space Preparation in Teeth Filled in Vivo with RealSeal Versus Gutta-Percha. J Endod. 2007;33:673-675.
27. Ruyter IE. Unpolymerized surface layers on sealants. Acta Odontol Scand. 1981;39:27–32.
28. Royer K, Liu XJ, Zhu Q, Malmstrom H, Ren YF. Apical and Root Canal Space Sealing Abilities of Resin and Glass Ionomer-Based Root Canal Obturation Systems. Chin J Dent

Res. 2013;16:47-53.
29. Saleh IM, Ruyter IE, Haapasalo M, Ørstavik D. Bacterial penetration along different root canal filling materials in the presence or absence of smear layer. Int Endod J. 2008;41:32-40.
30. Economides N, Kokorikos I, Kolokouris I, Panagiotis B, Gogos C. Comparative study of apical sealing ability of a new resin-based root canal sealer. J Endod. 2004;30:403-5.
31. Karapinar Kazandag M, Sunay H, Tanalp J, Bayirli G. Microleakage of various root filling systems by glucose filtration analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109:e96-e102.
32. Eldeniz AU, Orstavik D. A laboratory assessment of coronal bacterial leakage in root canals filled with new and conventional sealers. Int Endod J. 2009;42:303-12.
33. Rai K, Hegde MN, Hegde P. Apical sealing ability of newer resin based pulp space sealers- An in vitro study. Endodontology. 2009:16-21.
34. Chang JC, Hurst TL, Hart DA, Estey AW. 4-META use in Dentistry: a literature review. J Prosthet Dent. 2002;87:216–24.
35. Van Landuyt K, Snauwaert J, De Munck JD. Systematic review of the chemical composition of contemporary dental adhesives. Biomaterials. 2007;28:3757–85