2012

The Effect of Canal Preparation on Fill Length in Curved Root Canals Obturated With RealSeal 1 and Thermafil Plus

David Woodard
Medical University of South Carolina

The Effect of Canal Preparation on Fill Length in Curved Root Canals Obturated With RealSeal 1 and Thermafil Plus

David Woodard, D.D.S.

A thesis submitted to the faculty of the Medical University of South Carolina in partial fulfillment of the requirement for the degree of Master of Science in Dentistry in the College of Dental Medicine.

Department of Oral Rehabilitation
Division of Endodontics

2012

Approved by:

Joe W. Krayer, D.D.S., M.S., Chair

Marc E. Levitan, D.D.S.

Joseph E. Assad, D.D.S.

TABLE OF CONTENTS   Page

Acknowledgements

I would like to thank Dr. Marc Levitan, Dr. Joe Krayer and Dr. Assad for their insight, support and guidance throughout this study, as well as the American Association of Endodontists Foundation for their financial support. I want to thank Dr. Beth Wolf for her help with the statistical analysis and SybronEndo for donating materials for this project. Lastly, and most importantly, I want to thank my family for all of their support during this project.

DAVID RUSH WOODARD. The Effect of Canal Preparation on Fill Length in Curved Root Canals Obturated With RealSeal 1 and Thermafil Plus. (Under the direction of DR. MARC LEVITAN).

Introduction: A preparation technique allowing for a predictable thermoplastic obturation length while ensuring a three-dimensional fill would be of clinical value. **Methods:** This *in vitro* study was conducted using 80 extracted mature and patent human 1st and 2nd maxillary and mandibular molar teeth with mesiobuccal (MB) roots exhibiting 20°- 45° canal curvature using Schneider's method. Teeth were randomly divided into 4 experimental groups (n=20). Groups 1 and 3 were prepared using a standard taper preparation (STP) to size 40/04 at working length (WL). Groups 2 and 4 were prepared using a varied taper preparation (VTP) to size 40/02 at WL. Groups 1 and 2 were obturated with RealSeal 1™ (RS-1) per manufacturer's specifications. Groups 3 and 4 were obturated with Thermafil® Plus (TP) per verbal communication with the manufacturer. Extrusion of material was evaluated radiographically and microscopically (5X) and assessed ordinally as follows: (1) +/- 1.0 mm from WL, and (2) > 1.0 mm beyond WL. Statistical significance of data was set at $P = .05$. **Results:** The data for all groups showed statistically significant differences for overextension in STP groups compared to VTP groups (odds ratio STP:VTP=17.3:1) when controlling for type of material ($P < .001$), and for overextension in TP groups compared to RS-1 groups (odds ratio TP:RS-1=40:1) when controlling for type of preparation ($P < .001$). **Conclusions:** Results of this study

demonstrated using VTP compared to STP, and RS-1 compared to TP, in curved canals of MB molar roots significantly decreases the occurrence of extrusion while maintaining three-dimensional obturation of the root canal system. The clinical applications from this study include the following: when utilizing RS-1 either preparation type may be used and when using TP it is recommended to use a VTP to help minimize overextension of filling material.

Introduction

Instrumentation/Obturation Length Determination

Morphological Rationale

The key elements involved in root canal therapy are chemomechanically cleaning and shaping, and obturating the root canal system. One important component involved in this process is determining the apical extent of each canal to perform the key elements for the entire canal while avoiding involvement of the adjacent periapical (PA) tissues. Early anatomical studies found that the physiologic foramen, or canal terminus, was located at the cementodentinal junction (CDJ) of the root apex. It was determined that on average this CDJ was located about 1.0 mm coronal to the anatomical apex (1-8). Gani and Visvisian in 1999 showed that the canal morphology of each root of a maxillary molar varies from circular in the distobuccal (DB) root to circular and ovoid in the palatal root to flat, tear-shaped and ovoid in the MB root (9). Not only have studies shown the anatomical importance of staying within the canal but also the variations of anatomy that are present within canals.

Pathological Rationale

Teeth that have undergone pulpal and periapical pathosis have an effect on the length of a canal. Frank in 1990 and Malueg et al in 1996 showed that teeth with PA lesions had significantly more apical resorption than those without PA lesions (10-11).

These studies found that with apical resorption the apical anatomy of these roots, including the CDJ, gets altered and length determination based upon the location of the anatomical constriction of the canal becomes unreliable. Trope and Chivian in 1994 *confirmed this finding and also proposed that the apical CDJ is very thin, even absent in* some of these cases, and that this event exposes mineralized dentin to the resorptive cells leading to *the pathologic apical root resorptive process (12). In these situations,* the length of the canals for instrumenting and obturating becomes shorter and focus is placed on establishing a mechanical apical stop during instrumentation to prevent extrusion of filling material since the anatomical stop is no longer present.

Clinical Rationale

The endodontic literature contains studies that have assessed the outcome of root canal treatment dating from 1963. Seltzer and Bender in 1963 and 1967 found that overfilling of canals led to persistent PA inflammation (13-15). Davis and Joseph (1971) found that the most successful healing occurred in teeth that were completely instrumented, but filled short of the radiographic apex (16). Sjogren in 1990 looked at the success rates of necrotic teeth with apical periodontitis treated by root canal therapy and observed a 94% healing rate when the filling material was within 0 – 2.0 mm of the radiographic apex and a lower healing rate of 76% in canals that were overfilled (17). Ricucci in 1998 affirmed these earlier studies in a literature review article and a 100 case report series which concluded that the best healing occurred when filled to the apical constriction of the canal, 0.5 mm – 2.0 mm from the radiographic apex (18-19).

The apical extent of an instrument or obturating material in a root canal has been a topic of debate in the endodontic community for several years. Based on the aforementioned studies, some clinicians advocate choosing this point 1.0 - 2.0 mm short of a radiographic view of the canal apex. Other practitioners depend solely on an electronic apex locator (EAL) to identify their goal for determination of the canal's apical extent. Yet, there are a growing number of clinicians that utilize a combination of the radiographic view of the canal apex after obtaining the canal's apical measurements with an EAL.

Flow Properties of Thermoplastic Obturators

The study of the flow properties of matter, including heated materials, is termed rheology. When a heated material is placed under pressure, it can either become less viscous prior to cooling or act like a solution and get displaced by the active pressure. A heated material is termed thixotropic when it becomes less viscous under pressure and is able to revert back to its original state upon release of the applied force (20). In relating thixotropy to thermoplastic carrier obturation, heated obturators are inserted into the closed system of the canal at a constant rate for the length of the prepared canal and placed under a continuous and constant force to WL and over time revert back to the original solid state (21).

Gutta-percha is the most commonly used filling material in endodontics and has been extensively studied. In looking at gutta-percha, the unheated form is in the beta phase and is soft and compactable, but when it is heated above 65°C there is a phase transition that occurs from the beta to alpha phase. During the alpha phase, the gutta-percha is able to flow and easily compacted under force. Upon cooling, the gutta-percha reverts back to the beta phase and is not readily flowable under force (22).

Carrier-Based Technique

There are many techniques available for obturating root canal systems. One method is a carrier-based thermoplastic obturator format. This technique uses an obturation format that heats the obturator to provide a dense three-dimensional fill of the root canal system in a matter of seconds when inserted under pressure. However, one major disadvantage to carrier-based techniques is the tendency for extrusion of filling material beyond the canal into the surrounding PA tissues (23-28). This occurrence may be as a result of increased flow after heating the obturating material; but once extruded, the obturant is only retrievable by surgical means.

Thermafil Plus Obturators

An article in 1978 described the concept of the carrier technique by placing a stainless steel (SS) file coated with gutta-percha then heated prior to insertion into the root canal (29). In 1989, Thermafil (Tulsa Dental, Tulsa, OK) was developed based on this technique. Two years later, the stainless steel carriers were replaced with a resin-based polymer as the core carrier (30). The new carrier product was called Thermafil

Plus (Tulsa Dental, Tulsa, OK). TP obturators have become the standard for carrier-based thermoplasticized systems by which all other carrier-based thermoplastic obturation systems are measured.

RealSeal 1 Obturators

In the past few years, SybronEndo (Glendora, CA) developed the RealSeal 1 Bonded Obturator System. RS-1 is a new resin bonded carrier technique that utilizes the technology of Resilon (Pentron Clinical Technologies, Wallingford, CT), now called RealSeal (SybronEndo, Glendora, CA). The carrier is a polysulfone-containing polymer with radiopaque filler, and the surrounding Resilon-based filling material contains polycaprolactone and polyolefin polymers with radiopaque fillers (30). The RS-1 carrier system uses a methacrylate-based sealer called RealSeal SE™ Root Canal Sealant (SybronEndo) with the aim of achieving an adhesive bond to the root canal walls, filling material, and core resin carrier to achieve leakage resistance. SybronEndo's RS-1 carrier system is utilizing current resin bonding technology with the efficiency of a carrier-based thermoplasticized technique to obtain optimal resistance to leakage with a three-dimensional filling of the root canal system (30).

Root Canal Preparation Design

The current design for carrier-based thermoplastic obturator systems includes companion rotary file sizes (e.g., Tulsa Dentsply's Vortex™ Rotary Files, ProTaper® Universal, and GT® Rotary Files) which are matched to the obturator sizes. Most systems are based on STP with a particular size rotary file and taper to WL and a corresponding carrier which has the size and taper matched to the last rotary file used at WL. The majority of these systems include 0.04 and 0.06 taper rotary files to WL, but can have larger tapers such as Tulsa Dentsply's GT sizes of 0.10 and 0.12.

Purpose of Article

This study was designed to evaluate a VTP which utilizes (in a coronal to apical direction) 0.06, 0.04, and 0.02 tapers designed to provide a method of preventing the carrier and filling material from overextending into the PA tissues. The purpose of this *in vitro* study was to compare the overextension of filling material of 1st and 2nd maxillary and mandibular MB curved canals using two instrumentation techniques to obtain the final apical size: 40/04 (STP) and 40/02 (VTP); and using two carrier-based thermoplastic obturation systems: RS-1 and TP.

Materials and Methods

Selection and Preparation of Teeth

Eighty extracted mature and patent human first and second maxillary and mandibular molar teeth, with MB roots exhibiting 20°- 45° canal curvature, were randomly divided into 4 experimental groups (n=20). Schneider's method (31) was applied digitally by Emago® Digital Imaging Software (Oral Diagnostic Systems, Port Coquitlam, B.C.) by the use of Digora® OpTime Imaging Plates (Sordex, Milwaukee, WI). Groups 1 and 3 were prepared by a STP to size 40/04 at WL. Groups 2 and 4 were prepared by the VTP previously described to size 40/02 at WL. Groups 1 and 2 were obturated with RS-1 obturators per manufacturer's specifications. Groups 3 and 4 were obturated with TP obturators per verbal communication with the manufacturer because written instructions are not available. All samples were instrumented and obturated by the same individual.

Canal Length Determination

In all teeth, the canal length was established visually by placing a 15/02 K-file into the MB canal until the tip was visualized flush with the foramen with the aid of a Seiler IQ dental operating microscope (DOM) (5x) (Seiler Precision Microscopes, St. Louis, MO). After the file length was determined from a coronal reference point, the WL was established by subtracting 1.0 mm.

Canal Instrumentation

An Aseptico Model AEU-25 motor (Dentsply Tulsa Dental DTC, Tulsa, OK) was used at 600 rpm with a torque set at 750 g-cm and a rotary hand piece (8:1 ratio) was used for all rotary files in all samples. Groups 1 and 3 (STP) were prepared with a 25/10 K3 orifice shaper (SybronEndo, Glendora, CA) to enlarge the coronal portion of the canal, followed by a series of SybronEndo Twisted Files™ (Glendora, CA) to a final apical size of 40/04 per manufacturer's instructions. Groups 2 and 4 (VTP) were prepared with a 25/10 K3 orifice shaper, followed by an EndoSequence 40/06 rotary file (Brasseler USA®, Savannah, GA) to [WL – 3.0 mm] and a Twisted File 40/04 to [WL – 2.0 mm]. Then, the apical 2.0 mm were prepared with Triple-Flex SS hand files (SybronEndo, Glendora, CA) starting with 20/02 and enlarging the canal to the final apical size of

40/02. A 15/02 K-file was used for recapitulation following each hand and rotary file and again prior to obturation. 6% sodium hypochlorite (NaOCl) (Piggly Wiggly, LLC, Keene, NH) was diluted 50% with water to a 3% solution, and used alternately with SmearClear™ (SybronEndo, Glendora, CA) throughout the instrumentation of all samples. Distilled water was used to flush each canal following the use of either irrigation solution. A final irrigation included 10 mL of 3% NaOCl solution, 5 mL distilled water, 5 mL SmearClear and lastly a 5 mL rinse with distilled water. All canals were dried with size 40 Maxima® Absorbent Points #501 (Henry Schein®, Melville, NY).

Canal Obturation

Both obturator systems employ size verifier instruments. Prior to obturation, the size 40 verifier was used in all samples to insure that canals had been shaped to accommodate the corresponding size 40 obturator. All samples were obturated by one individual who was calibrated by stopwatch for both RS-1 and TP per manufacturer's recommendations. Sealer was placed into prepared and verified samples with size 40 Maxima absorbent points per manufacturer's instructions. Groups 1 and 2 were obturated with size 40 RS-1 obturators heated in the RealSeal 1 Oven (SybronEndo). Groups 3 and 4 were obturated with size 40 TP obturators using the ThermaPrep® Plus Oven (Dentsply Tulsa Dental). Immediately following obturation of each sample, 70% rubbing alcohol was syringed over the apex to rinse away excess sealer. All samples were then assessed for extension of filling material using the Seiler IQ DOM (5x), as well as exposing buccal and mesial radiographs processed by Emago Digital Imaging Software.

Extension Assessments

Extension of material was evaluated radiographically and microscopically (5X) and assessed ordinally as follows:

(1) +/- 1.0 mm from WL

(2) > 1.0 mm beyond WL

Statistical Analysis

Logistic regression was used to compare extension of filling material between the two preparation types and between the two types of filling material. All statistical analyses were conducted using SAS version 9.2 (SAS Institute Inc., Cary, NC). Statistical significance of data was set at $P = .05$.

Results

Data for groups 1-4 showed a statistically significant difference in both the preparation type ($P < .001$) and for the obturation system ($P < .001$). The odds ratio indicated that the odds of overextension in STP groups 1 and 3 are 17.3 times the odds of overextension in VTP groups 2 and 4 after controlling for type of filling material (95% Confidence Interval: 3.80 – 78.5) ($P < .001$). Also, the odds ratio of overextension with TP were 40 times the odds of overextension with RS-1 after controlling for the type of preparation (95% Confidence Interval: 6.78 – 237) ($P < .001$) (Fig. 1).

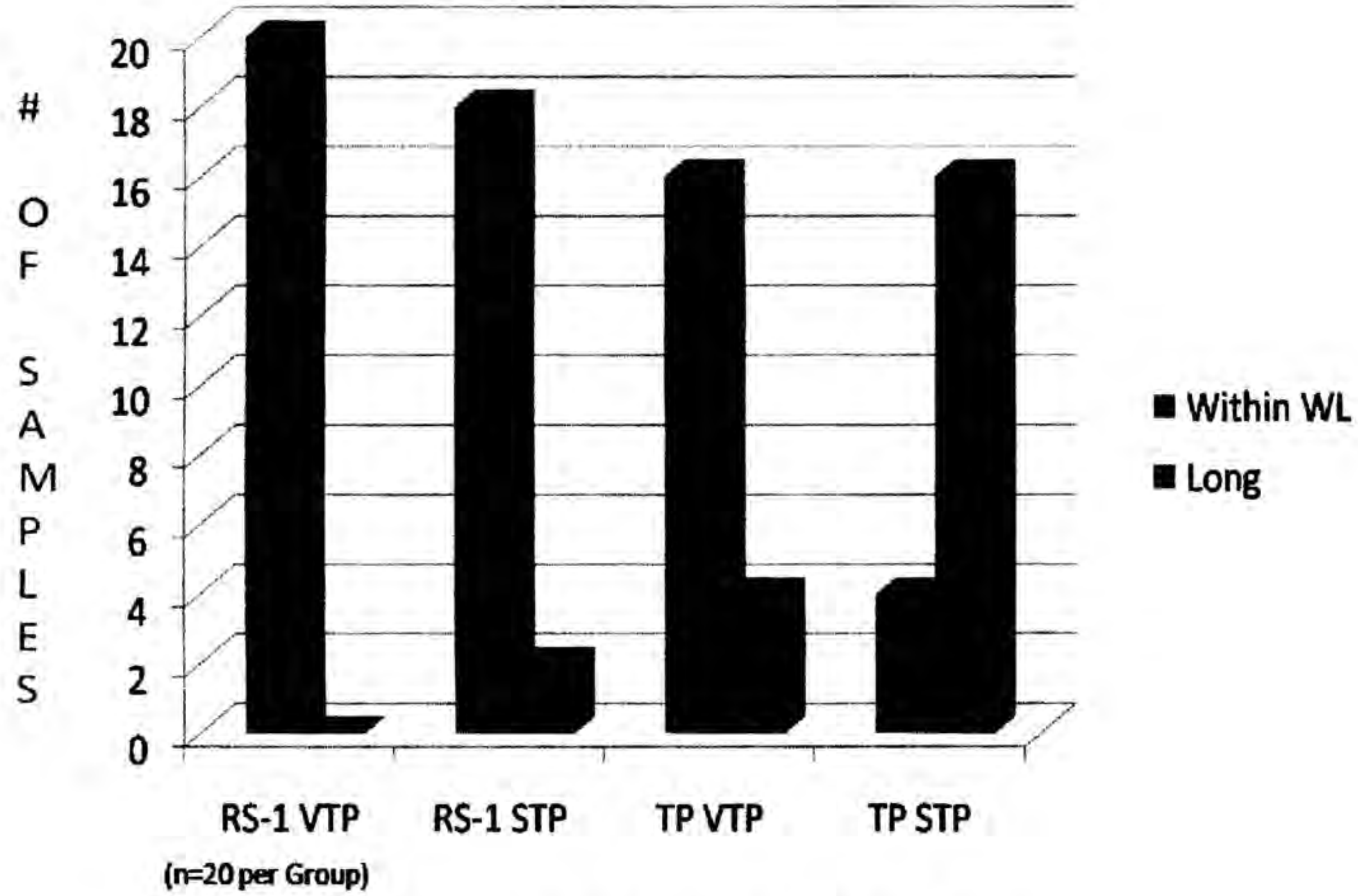

Figure 1. Extension results of RS-1 and TP using both preparation types (VTP and STP).

Discussion

The present study investigated the use of a new carrier system (RS-1) compared to a standard carrier system (TP) with either a STP or a VTP in curved canals to determine if there would be an effect on extrusion of filling material. The results indicated a statistically significant difference for both the type of preparation, VTP ($P < .001$), and for the type of filling material, RS-1 ($P < .001$), in producing less extrusion of filling material.

The application of a VTP in conjunction with the manufacturer's suggested rate of insertion was assessed to prevent the occurrence of overextension of filling material beyond WL and still obtain a three-dimensional obturation. The VTP begins with a 40/06 rotary file to [WL – 3.0 mm] followed by a 40/04 rotary file to [WL – 2.0 mm]. The apical 2.0 mm of the canal is instrumented with SS 0.02 taper hand files beginning with size 20/02 to a final master apical file size of 40/02.

Canal instrumentation in a crown-down technique from a 0.06 taper to a 0.02 taper takes into account the thixotropic properties involved with thermoplasticized filling materials. The heated thermoplasticized material removed from the oven and inserted into the canal is more flowable compared to its original solid state. The variable taper of the canal preparation allows the heated filling material to flow both vertically and laterally as it progresses down the canal. As this process continues, the heated filling material slows down and comes to a stop as the material cools over time and flows into the final and smallest taper of the preparation. Altogether, the factors affecting the thixotropy of a material are the time and pressure used to insert the heated carrier into the canal and the ability of the material to return to its original solid state upon cooling (20).

In clinical application, a constant rate of insertion from the orifice to WL results in the flow of filling material into the irregularities of the canal system. Combining this insertion rate with a VTP also provides a means of controlling the vertical flow to WL due to the thixotropic properties of the material and thereby avoiding overextension (21).

Having a treatment technique that confines the filling material within the root canal would help prevent the possibility of an unwarranted event, such as a foreign body reaction from the sealer and/or filling material extruded into the PA tissues (19). According to Ricucci's histological study in 1998, he found that when sealer and/or gutta-percha extruded outside of the canal there was a severe inflammatory reaction, even in the absence of pain (19). One goal of endodontic treatment is the prevention or treatment of apical periodontitis. Thus, the technique of performing a root canal should not add to the already (acute or chronic) inflammatory state of the periapex associated with a necrotic or irreversibly inflamed canal. This would only cause a hindrance or delay in the reparative process.

In conclusion, this study demonstrates a predictable outcome with a thermoplasticized carrier-based technique. The data indicates: 1) the RS-1 carrier-based system predictably exhibits less extrusion in 1^{st} and 2^{nd} maxillary and mandibular MB curved canals when compared to TP; and 2) the VTP design predictably exhibits less extrusion of filling material in 1^{st} and 2^{nd} maxillary and mandibular MB curved canals when compared to the STP. For clinical purposes, when using RS-1, either a VTP or a STP may be utilized. However, when using TP it is advisable to use a VTP to reduce the occurrence of extrusion of filling material.

The authors affirm that we have no financial affiliation (e.g., employment, direct payment, stock holdings, retainers, consultantships, patent licensing arrangements or honoraria), or involvement with any commercial organization with direct financial interest in this subject or materials discussed in this manuscript, nor have any such arrangements existed in the past three years. Any other potential conflict of interest is disclosed.

List of References

1. Kuttler, Y. "Microscopic investigation of root apexes." J. Am. Dent. Assoc. 50: 544-552, 1955.

2. Green, D. "A stereomicroscopic investigation of the root apices of 400 maxillary and mandibular anterior teeth." Oral Surg. Oral Med. Oral Pathol. 9: 1224-1232, 1956.

3. Green, D. "Stereomicroscopic study of 700 root apices of maxillary and mandibular posterior teeth." Oral Surg. Oral Med. Oral Pathol. 13: 728-733, 1960.

4. Burch, J.G., and S. Hulen. "The relationship of the apical foramen to the anatomic apex of the tooth root." Oral Surg. Oral Med. Oral Pathol. 34: 262-268, 1972.

5. Tamse, A., M.M. Littner, I. Kaffe, D. Moskona, and A. Gavish. "Morphological and radiographic study of the apical foramen in distal roots of mandibular molars. Part I. The location of the apical foramen on various root aspects." Int. Endod. J. 21: 205-210, 1988.

6. Tamse, A., M.M. Littner, I. Kaffe, D. Moskona, and A. Gavish. "Morphological and radiographic study of the apical foramen in distal roots of mandibular molars. Part II. The distance between the foramen and the root end." Int. Endod. J. 21: 211-217, 1988.

7. Stein, T.J., and J.F. Corcoran. "Anatomy of the root apex and its histologic changes with age." Oral Surg. Oral Med. Oral Pathol. 69: 238-242, 1990.

8. Dummer, P.M.H., J.H. McGinn, and D.G.Rees. "The position and topography of the apical canal constriction and apical foramen." Int. Endod. J. 17: 192-198, 1984.

9. Gani, O., and C. Visvisian. "Apical canal diameter in the first upper molar at various ages." J. Endod. 25: 689-691, 1999.

10. Frank, A.L. "Inflammatory resorption caused by an adjacent necrotic tooth." J. Endod. 16: 339-341, 1990.

11. Malueg, L.A., L.R. Wilcox, and W. Johnson. "Examination of external apical root resorption with scanning electron microscopy." Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 82: 89-93, 1996.

12. Trope, M., and N. Chivian. "Root Resorption." In: Pathways of the Pulp, edited by S. Cohen and R.C. Burns. St. Louis: Mosby, 1994, pgs. 493-501.

13. Seltzer, S., I.B. Bender, and S. Turkenkopf. "Factors affecting successful repair after root canal therapy." J. Am. Dent. Assoc. 67: 651-662, 1963.

14. Seltzer, S., I.B. Bender, J. Smith, I. Freedman, and H. Nazimov. "Endodontic failures – an analysis based on clinical, roentgenographic, and histologic findings. I." Oral Surg. Oral Med. Oral Pathol. 23: 500-516, 1967.

15. Seltzer, S., I.B. Bender, J. Smith, I. Freedman, and H. Nazimov. "Endodontic failures – an analysis based on clinical, roentgenographic, and histologic findings. II." Oral Surg. Oral Med. Oral Pathol. 23: 517-530, 1967.

16. Davis, M.S., S.W. Joseph, and J.F. Bucher. "Periapical and intracanal healing following incomplete root canal fillings in dogs." Oral Surg. Oral Med. Oral Pathol. 31: 662-675, 1971.

17. Sjogren, U., B. Hagglund, G. Sundqvist, and K. Wing. "Factors affecting the long-term results of endodontic treatment." J. Endod. 16: 498-504, 1990.

18. Ricucci, D. "Apical limit of root canal instrumentation and obturation, part 1. Literature review." Int. Endod. J. 31: 384-393, 1998.

19. Ricucci, D., and K. Langeland. "Apical limit of root canal instrumentation and obturation, part 2. A histological study." Int. Endod. J. 31: 394-409, 1998.

20. Lee, C.H., V. Moturi, and Y. Lee. "Review. Thixotropic property in pharmaceutical formulations." J. Control. Release 136: 88-98, 2009.

21. Levitan, M.E., V.T. Himel, and J.B. Luckey. "The effect of insertion rates on fill length and adaptation of a thermoplasticized gutta-percha technique." J. Endod. 29: 505-508, 2003.

22. Metzger, Z., B. Basrani, and H.E. Goodis. "Instruments, Materials, and Devices." In: Pathways of the Pulp, edited by K. Hargreaves and S. Cohen. St. Louis: Mosby, 2011, p. 260.

23. Dummer, P.M.H., T. Kelly, A. Meghji, I. Sheikh, and J.T. Vanitchai. "An in vitro study of the quality of root fillings in teeth obturated by lateral condensation of gutta-percha or Thermafil obturators." Int. Endod. J. 26: 99-105, 1993.

24. Scott, A.C., and D.E. Vire. "An evaluation of the ability of a dentin plug to control extrusion of thermoplasticized gutta-percha." J. Endod. 18: 52-57, 1992.

25. Gutmann, J.L., W.P. Saunders, E.M. Saunders, and L. Nguyen. "An assessment of the plastic Thermafil obturation technique. Part 1. Radiographic evaluation of adaptation and placement." Int. Endod. J. 26: 173-178, 1993.

26. Clark, D.S., and M. ElDeeb. "Apical sealing ability of metal versus plastic carrier Thermafil obturators." J. Endod. 19: 4-9, 1993.

27. Schäfer, E., and G. Olthoff. "Effect of three different sealers on the sealing ability of both Thermafil obturators and cold laterally compacted gutta-percha." J. Endod. 28: 638-642, 2002.

28. Robinson, M.J., N. J. McDonald, and P.J. Mullally. "Apical extrusion of thermoplasticized obturating material in canals instrumented with Profile 0.06 or Profile GT." J. Endod. 30: 418-421, 2004.

29. Johnson, W.B. "A new gutta-percha technique." J. Endod. 4: 184-188, 1978.

30. Duggan, D., R.R. Arnold, F.B. Teixeira, D.J. Caplan, and P. Tawil. "Periapical inflammation and bacterial penetration after coronal inoculation of dog roots filled with RealSeal 1 or Thermafil." J. Endod. 35: 852-857, 2009.

31. Schneider, S.W. "A comparison of canal preparations in straight and curved root canals." Oral Surg. Oral Med. Oral Pathol. 32: 271-275, 1971.