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Apical Leakage of a New Root Canal Sealer

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Apical Leakage of a New Root Canal Sealer

Nathan E. Beam

Thesis Submitted to the
School of Dentistry
At West Virginia University
in partial fulfillment of the requirements
for the degree of

Master of Science
In
Endodontics

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ABSTRACT

Apical Leakage of a New Endodontic Root Canal Sealer

Nathan E. Beam

A new endodontic root canal sealer, iRoot SP, has been introduced. This bioceramic root canal sealer claims to be a superior sealing and filling material for root canals. Although the manufacturer advocates the use of a single cone technique with this sealer, they state that it may also be used with lateral compaction and warm vertical condensation. The purpose of this study was to compare in vitro apical microleakage of iRoot SP root canal sealer to AH Plus sealer when used in conjunction with a single cone technique and lateral compaction technique.

Eighty six mesial roots of mandibular molar teeth with mature apices were randomly divided into four experimental groups along with a positive and negative control groups. Teeth were cleaned and sectioned at the CEJ with high speed hand piece and water coolant. All teeth were pre-flared with S1 and S2 Protaper Universal (DENTSPLY[®]) NiTi rotary files. Then the teeth were instrumented to a #30 .06 taper master apical file with Brasseler[®] Endosequence Niti rotary files in a crown down technique. Teeth were then divided into the groups: Group A- lateral condensation technique with iRoot Sp, Groups B- lateral condensation with AH Plus, Group C- single cone technique with iRoot SP, Group D- single cone with AH Plus, positive control (obturation with no sealer), and negative control (no obturation with two layers of varnish covering entire root). Teeth were allowed to soak in 1 % methylene blue dye under vacuum (390 torr) and for an additional 7 days once the seal was broken. The clearing process consisted of 24 hours in 5% nitric acid, 24 hours in 80% ethyl alcohol, 24 hours in 99.8% ethyl alcohol, and the roots became transparent after 48 hours in 99 % methyl salicylate. Two second year endodontic residents along with a dental hygienist graded the apical dye penetration a measuring microscope.

None of the negative controls showed any leakage and all of the positive control showed leakage the entire length of the root. Of the 86 specimens starting the study, 4 did not clear properly and were excluded from the study leaving a total of 82. In the iRoot SP group, the mean apical leakage in group A was 0.83mm +/- 0.15, and 0.63mm +/- 0.13 for group C. In the AH Plus group, the mean apical leakage was 1.63mm +/- 0.13 in group B, and 0.42mm +/- 0.14 in group D.

Comparable levels of apical leakage were found between iRoot SP (single cone and lateral compaction) and AH plus single cone. AH plus with lateral compaction had statistically more apical dye leakage than the other groups. None of the negative controls showed any leakage and all of the positive controls demonstrated leakage supporting the experimental design. This in vitro study supports the use of the sealers AH Plus or iRoot SP in combination with .06 taper gutta-percha points in the obturation of .06 canal preparations.

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Chapter I

INTRODUCTION

One of the primary objectives of conventional endodontic therapy is to achieve the total obturation of the root canal space. However, incomplete obturation of the root canal system still accounts for nearly 60 % of all endodontic failures (1, 2). According to Weine (3), the most common cause of endodontic failure can be attributed to the lack of an adequate apical seal. Over the years, many different obturation techniques have been tested and utilized in hopes of increasing the quality of the apical seal.

Lateral condensation of gutta-percha is at present the most widely used method of obturation (4), and in a survey of Diplomates of the American Board of Endodontics, Taintor and Ross (5) found that the majority of respondents considered lateral condensation to be the preferred method of obturation. Lateral condensation provides an apical seal that is as good or better than numerous other obturation techniques, and this has been consistently proven over the years (6, 7, 8, 9, 10, and 11). Advantages to this technique include predictability, relative ease of use, conservative preparations, and controlled placement of materials. Even when performed properly, the primary disadvantage to lateral condensation is the inability to adapt the mass of gutta-percha to the cul-de-sacs, fins, and accessory and lateral canals of the root canal system. For this reason, lateral condensation, in common with all other obturation techniques, must use a root canal sealer to obtain a fluid tight seal. This fact is supported by numerous studies, all of which have clearly demonstrated that a sealer must be used in

conjunction with all obturation techniques, thus improving the apical seal significantly (9, 12, 13, 14).

Root canal sealers are used to fill any irregularities between the mass of the gutta-percha filling material and the prepared canal walls. A sealer also functions as a lubricant during placement of the gutta-percha within the main canal and may fill accessory canals or multiple foramina. Currently, there are no sealers that possess all of the optimal properties required to be considered an ideal root canal sealer. A new obturation sealer, iRoot SP root canal sealer (Innovative Biocreemix Inc, Vancouver, Canada and marketed as BC sealer by Endosequence in the USA) has been introduced. According to the manufacturer's description, iRoot SP is a convenient, premixed, ready-to-use injectable, white, hydraulic cement paste developed for permanent root canal fillings. iRoot SP is an insoluble, radiopaque, aluminum free material based on a calcium silicate composition, which requires the presence of water to set and harden. The makers of iRoot SP claim it to be superior to all other sealers in fulfilling the requirements of "the ideal root canal sealer".

STATEMENT OF THE PROBLEM

Is there is a difference in the apical leakage of a single cone obturation in combination with iRoot SP sealer when compared to lateral compaction with AH Plus sealer?

SIGNIFICANCE OF THE PROBLEM

One of the most commonly used ways to obturate the root canal space is the lateral condensation of gutta-percha. This technique, in combination with AH Plus sealer, has been proven to provide an optimal apical seal with clinically acceptable apical leakage when completed correctly. Short falls of the technique are: (1) the inability to compact gutta-percha to within several millimeters in curved roots; (2) compaction forces may cause vertical root fractures(VRF); and (3) sealer shrinkage, which may lead to a compromised apical seal.

The manufacturer of iRoot SP claims the sealer to be user-friendly, biocompatible, anti-bacterial, with no shrinkage, with small particle size that allows it to flow into all cul-de-sacs, fins and accessory canals with a single gutta-percha master cone. If these characteristics are true, it will make the procedure more successful with less time required to accomplish the stated goals.

NULL HYPOTHESIS

There is no significant difference in apical leakage between iRoot SP sealer (single cone) and AH Plus sealer (lateral condensation).

DEFINITION OF THE TERMS

Actual tooth length: The measured length, from the reference point, of a file placed in the canal until its tip becomes visible at the apical foramen using 3.5X magnification.

Cold lateral condensation: An obturation technique which involves the placement of sealer in the canal, followed by a measured master gutta-percha point, which is laterally condensed by a spreader to make room for additional gutta-percha points.

Crown down technique: A technique of canal instrumentation which enlarges the coronal portion of the canal in the initial stages of mechanical preparation. The canal is enlarged in a step-wise fashion from the coronal orifice towards the apical foramen with progressively smaller files until the desired length is achieved.

Leakage: A qualitative description of the presence of methylene blue dye coronal to the end point of the gutta-percha, as visualized microscopically.

Linear apical leakage: A quantitative measurement of the maximum penetration of the dye from the apical endpoint of the master gutta-percha cone, in the coronal direction.

Reference point: A repeatably reproducibly recognized flat landmark identified at the coronal orifice created when the tooth is sectioned at the CEJ.

Rotary instrumentation: A technique of canal instrumentation which utilizes an engine driven handpiece to rotate endodontic files in a 360 degree clockwise direction.

Single cone obturation: Obturation of the canal space utilizing a single gutta-percha cone that is manufactured to be the same size as the largest file used to the apex, along with an endodontic sealer.

Taper: A descriptive term for the smooth increase in diameter of a conical object from its smallest diameter to its largest diameter.

Working length: (WL), The length determined by subtracting 1.0 mm from the actual tooth length.

Master Apical File: (MAF), The largest file used at the working length to clean and shape the canal.

Apical percolation: Bacteria and/or byproducts that are able to pass through the obturation material at the apex of an endodontically treated tooth.

ASSUMPTIONS

- 1) Lateral condensation of gutta-percha is the most commonly used technique.
- 2) The lateral condensation technique results in a clinically acceptable apical seal.
- 3) All sealers have some degree of shrinkage.
- 4) AH Plus has been shown to possess equal to or superior sealing abilities than other commonly used sealers.
- 5) Apical leakage causes apical periodontitis.
- 6) Single cone obturation technique is easier and quicker than cold lateral condensation techniques.
- 7) An apical dye leakage study is an appropriate indicator of the quality of the apical seal.

LIMITATIONS

- 1) An in vitro experiment is simulating an in vivo situation.
- 2) There is a human element in performing these techniques.
- 3) The root canals used will be similar, but will not have identical morphology.
- 4) Individual root canal system variability could affect the instrumentation and obturation quality of any given tooth.

DELIMITATIONS

- 1) The extracted teeth were selected carefully in an attempt to minimize variability.
- 2) Mesial buccal roots of mandibular molars were selected
- 3) Selected teeth had completely formed apices

- 4) Any tooth which allowed a #30 .02 taper ISO file to pass through the apical foramen was eliminated.
- 5) Teeth were sectioned at the CEJ to allow optimal straight line access.
- 6) All instrumentation and obturation were performed by the principal investigator.
- 7) Sealer was allowed to set for 72 hours in a 100% humidity environment.
- 8) Apical leakage was determined after the teeth were suspended in methylene blue dye under vacuum for 24 hours and an additional 7 days after the seals broken.
- 9) A clearing method was used to visualize the dye leakage using a measuring microscope.
- 10) Measurements of leakage will be done independently by two second year endodontic residents and a dental hygienist without knowledge from which experimental group each tooth originated.

CHAPTER II

REVIEW OF LITERATURE

The goal of endodontic therapy is the complete cleaning and shaping of the root canal system, development of a fluid tight seal the entire length of the system, and complete obliteration of the root canal space. It is impossible to remove all toxins through debridement alone due to fins and deltas associated with most root canal systems (15). Any bacteria or toxins left in the canal must be isolated by obturation so that they are prevented from reaching the periapical tissues. The apical seal must prevent leakage between the root canal system and the periapical tissues in order to prevent bacteria from using the available fluid as a substrate (16). The seal obtained during obturation must also be protected from coronal microleakage. Coronal microleakage has been found to be an important factor in endodontic success (17, 18).

The overall success rate for endodontic therapy is dependent on several factors including, but not limited to, placement of root canal fillings in relation to the anatomical apex, canal sealing ability of technique and material, and quality of coronal restoration. Swartz et al reported an overall success rate of 90% in his study. He evaluated over 1000 teeth, clinically and radiographically, in a twenty year retrospective study, concluding that overfilled canals were four times more likely to result in failure than canals filled short of the radiographic apex (17). According to Ingle, the most common cause of endodontic failure is apical percolation caused by incomplete obturation. The "Washington study" showed that 59% of endodontic failures were due to incomplete obturation (18). Barbakow found an overall success rate of

87%, with short fills slightly less successful (76%) than overfills (82%) (19). Morse found an overall success rate of 95% and concluded that flush fills and overfills were more successful than underfills (20).

Although the apical seal is important, the long-term success or failure of endodontic treatment depends to a large degree on the quality of the coronal restoration and the reduction of bacteria during the cleaning and shaping phase. Swartz reported that endodontic failure was twice as likely to occur when an inadequate coronal restoration was present (17). Ray and Trope determined that the most important factor for endodontic success is not the quality of the endodontic treatment, but the quality of the coronal restoration. They examined the radiographs of over 1000 teeth that had been treated endodontically and concluded that radiographic evidence of periapical inflammation was present less often when there was a combination of good root canal therapy with a good coronal restoration. Teeth with well performed endodontic therapy that were restored with a poor coronal restoration had more periapical inflammation than teeth with poor endodontic therapy and good coronal restoration (21).

Currently in endodontics, gutta percha is used in conjunction with an endodontic sealer to obturate the root canal system. The gutta-percha is used to fill the large space in the canal and to force the sealer into the fins, apical deltas, and lateral canals. Cold lateral condensation of gutta-percha is the most common obturation technique. Advantages of this technique include its predictability, length control, and ease of use. Disadvantages include the inability to produce a homogenous mass, potential void when accessory cones do not reach the depth of

spreader penetration, and less adaptation to canal irregularities (22). Lateral condensation is often used as a control for evaluating the sealing ability of new obturation techniques (23).

The conventional root-filling technique taught in most dental schools has been the cold lateral condensation technique using an ISO .02 tapered, standardized gutta-percha point as the master cone, supplemented with accessory cones (24, 25). However, many practitioners considered this method time consuming and technique sensitive.

The single-cone technique, on the other hand, is faster and easier to perform. However, single-cone techniques performed with conventional sealers have been perceived to be less effective in sealing root canals than the gutta-percha warm vertical compaction technique (26). The single cone method has gained popularity in some European countries (27) but has been considered inferior to the lateral compaction technique as described in some textbooks (28). Some in vitro studies on dye penetration along root fillings have shown that the single-cone technique permitted more leakage than the cold lateral technique (26, 29), whereas others using a leakage technique with fluid movement did not find a difference after root filling of oval-shaped canals (30). Results from an in vivo study showed no significant difference in treatment outcome between single-cone and lateral compaction techniques after 6 to 18 months (35).

In these previous studies, shaping of the root canals was performed by hand instrumentation with stainless-steel instruments. However, noncompaction, single-cone filling of root canals has recently been revived (32, 33) with the introduction of “greater taper”

master cones that closely match the geometry of nickel–titanium instrumentation systems (34). Preparation of the root canal with rotary nickel-titanium (Ni-Ti) instruments may improve the adaptation between gutta-percha point and the canal wall because the flexible Ni-Ti instruments may result in less straightening and flaring of curved canals compared with the use of stainless steel instruments (35,36,37,38,39). The use of rotary instruments may also improve preparation of a uniformly round space compared with circumferential filling produced with hand instruments, although the cleaning efficacy, however, may depend on canal morphology (40, 41, and 42). Thus, a .06 taper single-cone technique used after canal preparation with .06 tapered rotary instruments was found to be comparable to lateral compaction in a recent laboratory study on simulated canals and mesiobuccal maxillary molar canals (33). The advent of contemporary root canal sealing systems that claim to create bonds along the sealer–gutta-percha interface by modifications of the sealer or the root-filling material may also support the use of a single-cone obturation technique (43).

It has been shown in several studies that the use of a sealer with gutta-percha significantly increases the apical sealing abilities of all techniques (9,12,13,14). Before a root canal sealer can be considered for use, it must possess certain desirable characteristics. Grossman (44) identified eleven requirements for the ideal root canal sealer. The root canal sealer should: 1) provide an excellent seal when set; 2) produce adequate adhesion between the sealer, the canal wall, and the filling material; 3) be radiopaque; (4) be nonstaining; (5) be dimensionally stable; (6) be easily mixed and introduced into the canal; (7) be easily removed if necessary; (8) be insoluble in tissue fluids; (9) be bactericidal or discourage bacterial growth;

(10) be non-irritating to periapical tissue; (11) be slow setting, to ensure sufficient working time. Currently none of the available endodontic sealers have all eleven characteristics (45).

Although none of the root canal sealers currently available possess all of the ideal properties, there are many which function adequately with respect to clinical performance. One of the commonly used control sealers that have been used in many apical leakage studies is AH Plus (46, 47, 48). AH Plus is an epoxy resin cement that has been proven to be acceptable. It has been shown to have superior or equal apical sealing ability when tested against other commonly used sealers (47, 48).

Even though there are currently several acceptable endodontic sealers available, there is a continuous search for newly developed products that are improved and more predictable than existing ones. Bioceramic obturation materials are the latest addition to the dentist's arsenal. The science associated with bioceramic technology has helped to develop several biocompatible ceramic material used in dentistry and medicine. Research of ceramics for the use in biomedical applications began in the early 1970's, and for the past forty years, the application of ceramics in biomedicine has been expanding(49). "Bioceramics" are composed of alumina and zirconia, bioactive glass, glass ceramic, calcium silicates, coatings and composites, hydroxapatite and resorbable calcium phosphates, and radiotherapy glasses(50,51,52). Bioceramics are currently being used in orthopedics in applications such as joint or tissue replacement, and for coating implants for improving biocompatibility. Bone defects are being filled with porous ceramics such as calcium phosphate. In dentistry, calcium silicates (MTA) are being used with great biocompatibility, sealability, and success(53).

iRoot SP is a new bioceramic endodontic sealer, with some of the advantages claimed by the manufacturer (Endosequence BC Sealer) to be: (1) enhanced biocompatibility, (2) no shrinkage, (3) non-resorbable (which is critical for a one-cone technique), (4) high pH (12.8) during the initial 24 hours of the setting process (which is strongly anti-bacterial), (5) excellent sealing ability, (6) quick setting time (3 to 4 hours) and (7) ease of use (particle size is small enough to allow for use in a syringe). The high pH makes this material very antibacterial during its setting period (the pH decreases over the following days). This is an important physical property for a dental cement, particularly if it is being used as an endodontic sealer (53). In another study by Zhang et al (46), it was noted that the BC Sealer (iRoot SP) killed all bacteria within 2 minutes of contact. The authors proceed to opine that the antibacterial effect might be a combination of high pH, hydrophilicity, and active calcium hydroxide diffusion (46). There is very little literature on the new endodontic sealer, but if current claims are true, iRoot SP should have equal or better apical sealing properties when compared to the other commonly used sealers, with the added advantage of having additional biocompatible characteristics.

Permeability of the apical seal has been previously demonstrated by dye penetration (54,55), radioisotope penetration (56,57), electrochemical means (58), microbiological invasion (59), fluorometric measurements (60), and scanning electron microscopic examination (61). Evaluation of dye penetration continues to be a commonly used technique to assess the quality of the apical seal. Matloff found that a dye penetrated farther coronally than did radioisotopes (62). Studies have suggested that a vacuum must be applied to remove any trapped air inside the canal which could hinder the penetration of a dye (63,64). Kersten and Moorer found that dyes used to evaluate leakage contain much smaller particles than the average bacteria size

associated with endodontics. They summarized that microleakage of small particles is unlikely to play a role in periapical disease, but leakage of high molecular weight substances of bacteria-sized particles is an important factor (65). Hovland and Dumsha concluded that all root canal sealers leak to some degree. They believe that there is a critical level of leakage that is unacceptable for healing, and failure to achieve an adequate seal results in endodontic failure. Leakage may occur at the interface of the dentin and sealer, at the interface of the semisolid core and sealer, through the sealer itself, or by complete or partial dissolution of the sealer (66).

Dye penetration has been examined by several methods of visualization. Eldeeb suggested that the longitudinal sectioning of roots would not allow the examiner to measure leakage accurately, and that the examiner could get a false impression of under-penetration unless the plane of sectioning reveals the area of deepest penetration (67). Cross-sectioning of the root has been utilized in several leakage studies (68). A disadvantage of this technique is that tooth structure is lost during cutting of the root and measurement of maximum penetration could again be incorrect. Robertson developed a clearing technique which was slightly altered by Roda and Gutmann (69, 70). This technique allows the microscopic visualization of dye penetration around the circumference of the entire canal.

CHAPTER III

MATERIAL AND METHODS

Eighty-six mesial roots of human mandibular molar teeth with mature apices were assigned to four experimental groups along with positive and negative control groups. The teeth were cleaned of extraneous tissue and calculus and then stored in 5.25% NaOCl for 24 hours to dissolve any soft tissue remaining on the root surface. Crowns of the teeth were sectioned at the CEJ with a high speed hand piece with a #1958 carbide bur (Midwest burs[®]) with continuous water spray. A #15 K-file (KontrolFlex series II by Brasseler USA[®]) was used to locate the apical foramen and 1.0 mm was subtracted from the actual root canal length to determine the working length.

The coronal and middle thirds of operated canals were first flared utilizing Protaper[®] (Tulsa Dental Specialties) Shaping file 1 and Shaping file 2 (both rotary files were used to the working length). To ensure patency of the apical foramen through out the procedure a #15 K-file was passed through the apical foramen after the use of each rotary file size. Sodium hypochlorite (5.25%) was used as the irrigant and was delivered into the canal with 5cc Luer Lok syringe, with constant flushing and suction, and was left in the canal during all instrumentation. All teeth were instrumented to master apical file (MAF) of #30 with Endosequence (by Brasseler USA[®]) .06 taper nickel titanium rotary files in a crown down technique. All teeth were dried with paper point until no signs of moisture were apparent on the paper point.

Obturation of the canals

Teeth were randomly assigned to four groups of twenty. Three teeth were set aside for a negative control group and another three for the positive control group.

Group A: Lateral condensation technique with iRoot SP sealer. Prior to master cone placement sealer was delivered to the coronal two thirds of the canal according to manufacturer's instructions. The apical half of each .04 taper Bioceramic gutta-percha master cone (Brasseler® Endosequence) was coated with sealer, placed in the canal, and slowly placed to working length. A #30 spreader was inserted into the canal 1-2 mm short of working length and lateral condensation was carried out in the normal manner until the entire canal was satisfactorily obturated.

Group B: Lateral condensation technique with AH Plus sealer. The specimens in group B were obturated in a similar manner as in group A, but with AH Plus as the sealer.

Group C: Single cone technique with iRoot SP sealer. Canals were obturated with a single .06 taper Bioceramic gutta-percha master cone (Brasseler® Endosequence) that matched the last file size used in the instrumentation of the canal. Next, iRoot SP was injected into the coronal two thirds as per manufacturer's instructions. The apical half of the prefitted master cone was coated with sealer and introduced into the canal and slowly placed to working length.

Group D: Single cone technique with AH Plus sealer. The canals in group D were obturated in a similar manner as in group C, but with AH Plus as the sealer.

Positive control: Canals were obturated with gutta-percha in a lateral condensation technique without sealer.

Negative control: Canals were not obturated, but the entire roots were covered with two layers of nail polish.

After obturation the gutta-percha was seared off 3mm below access opening, which was then sealed with Permaflo[®] Purple anatomical indicating composite by ultradent. All specimens were stored in a humidior for 72 hours with 100% humidity at room temperature to allow the sealer to set. Teeth were allowed to air dry and then coated with nail polish except for the apical 1-2 mm of the root. The roots were immersed in 1% methylene blue dye solution and then were placed under a vacuum pressure of 390 torr for 24 hours. The specimens were allowed to soak for 7 more days in the dye solution after the vacuum was broken. Next, the roots were rinsed with saline and the nail polish was removed with acetone. The specimens were then stored in saline until the clearing process.

CLEARING PROCESS

All teeth were cleared for evaluation using a technique described by Roda and Gutmann. Specimens were placed in 5% nitric acid for 24 hours to decalcify the roots. The roots were then dehydrated by being placed in 80 % ethyl alcohol for 24 hours followed by 24 hours in 99.8 % ethyl alcohol. Clearing of the roots was accomplished by covering the entire specimens in methyl salicylate. Roots became transparent after 48 hours in the 99 % methyl salicylate. The specimens were then stored in the methyl salicylate until evaluated for dye

penetration. Each container was numbered in a manner so that the graders could not identify which group they were in.

DATA COLLECTION

Two second year endodontic residents and one dental hygienist independently evaluated leakage using a measuring microscope at 15x power. Linear measurements were made, to the nearest 0.01mm, from the apical terminus of the gutta-percha to the most coronal extent of the dye penetration. Each investigator recorded the measurements on a data collection sheet as shown in appendix A. A measurement of 0.00mm indicated no leakage coronal to the endpoint of the gutta-percha, and 15mm was indicated if leakage penetrated the entire length of the root.

STATISTICS

Pearson test was used to determine if difference existed between graders. Differences between groups were analyzed with ANOVA and Tukey HSD (Honestly Significant Difference) test using JMP8 software (SAS Institute, Cary, NC) at alpha of 0.05.

CHAPTER IV

RESULTS

Interrater Reliability

The Pearson's correlation coefficients showed consistency between graders for all the teeth in each of the four groups. In each case, $r > 0.87$ and $p < 0.001$ (see Table 1); demonstrating a high correlation between the raters. This permitted calculation of an average rating for each tooth.

Leakage

None of the negative controls showed any leakage and all of the positive control showed leakage the entire length of the root. Of the 86 specimens starting the study 4 did not clear properly and were excluded from the study leaving a total of 82. In the iRoot SP group, the mean apical leakage in group A was 0.83mm +/- 0.15, and 0.63mm +/- 0.13 for group C. In the AH Plus group, the mean apical leakage was 1.63mm +/- 0.13 in group B, and 0.42mm +/- 0.14 in group D. Table 2 and Figures 1 and 2 summarize the mean values for linear dye penetration for the four groups. The test groups were subjected to an analysis of variance shown in Table 3. The test did show that one of the groups was significantly different from the others. The Tukey's HSD (Honestly Significant Difference) test was performed to find the group that was different (Table 2). There were no significant differences between groups A, C, and D. There was significant more apical leakage in group B when compared to all other groups. Values of each group by grader are shown in Figures 3, 4, 5 and 6.

Table 1- Pearson Correlation Coefficient

Variable	by Variable	Correlation	Significant Prob
Grader 2	Grader 1	0.8740	<.0001
Grader 3	Grader 1	0.8888	<.0001
Grader 3	Grader 2	0.9303	<.0001

Figure 1- Mean Value of Linear Dye Penetration

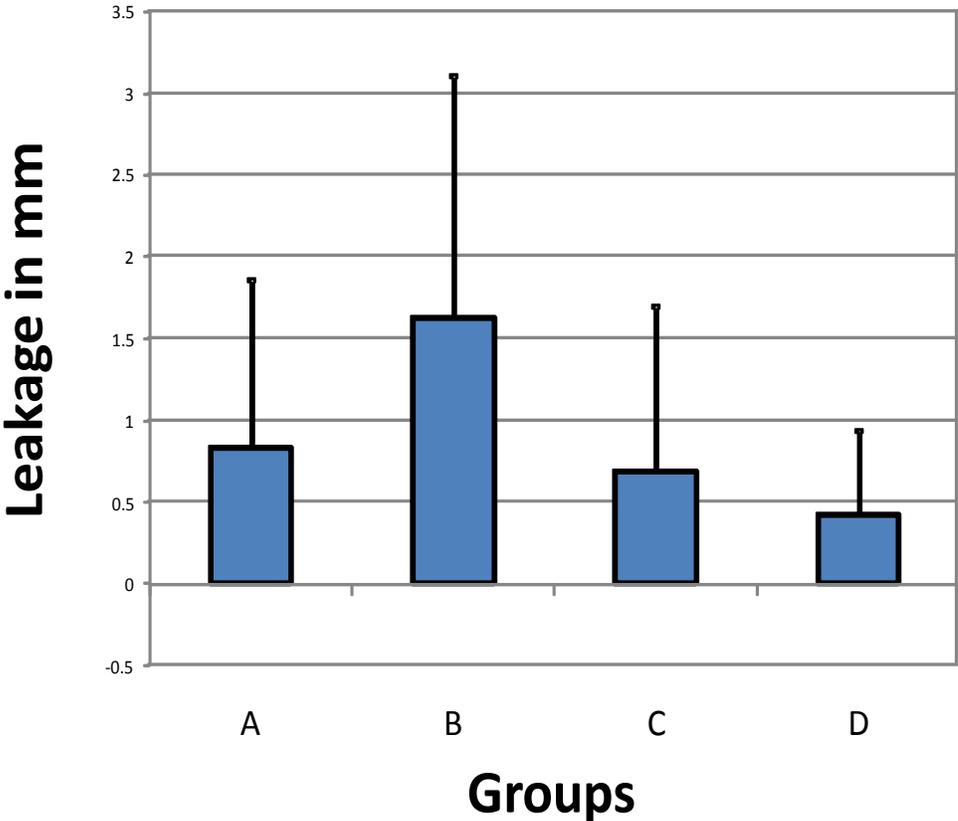


Figure 2- Mean Value of Linear Dye Penetration

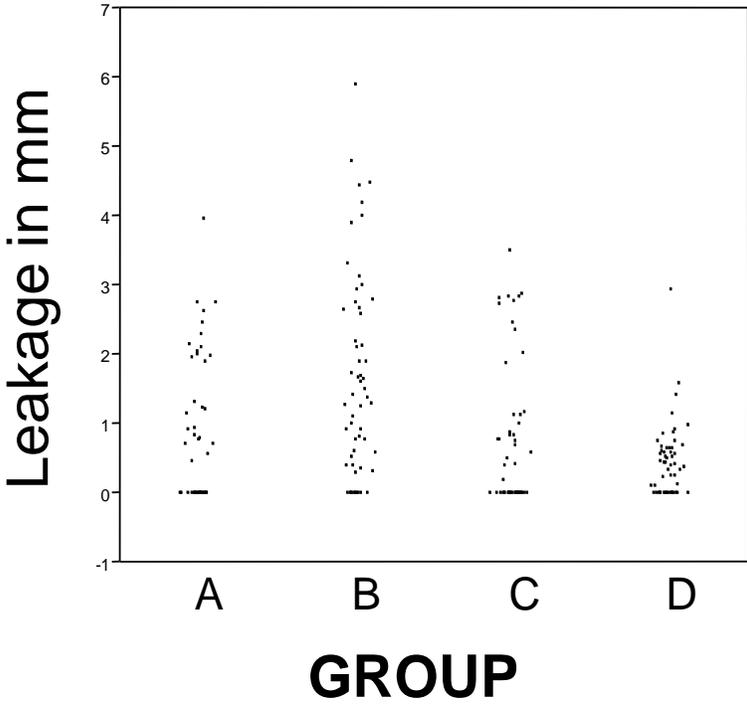


Table 2- Tukey's Honestly Significant Difference

Group	Mean(score)	Standard Deviation	Tukey result
A	0.83	1.03	y
B	1.63	1.48	z
C	0.68	1.01	y
D	0.42	0.52	y

Table 3- ANOVA

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
GROUP	3	3	47.941857	13.8542	<.0001*

Figure 3- Group A- Dye Penetration by Grader

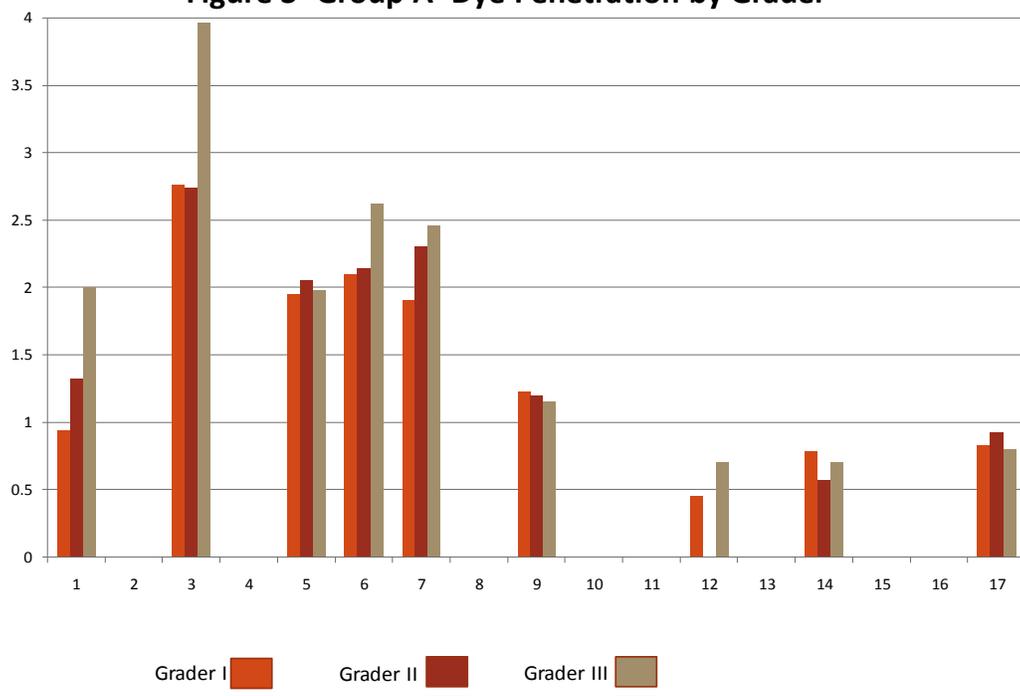


Figure 4- Group B- Dye Penetration by Grader

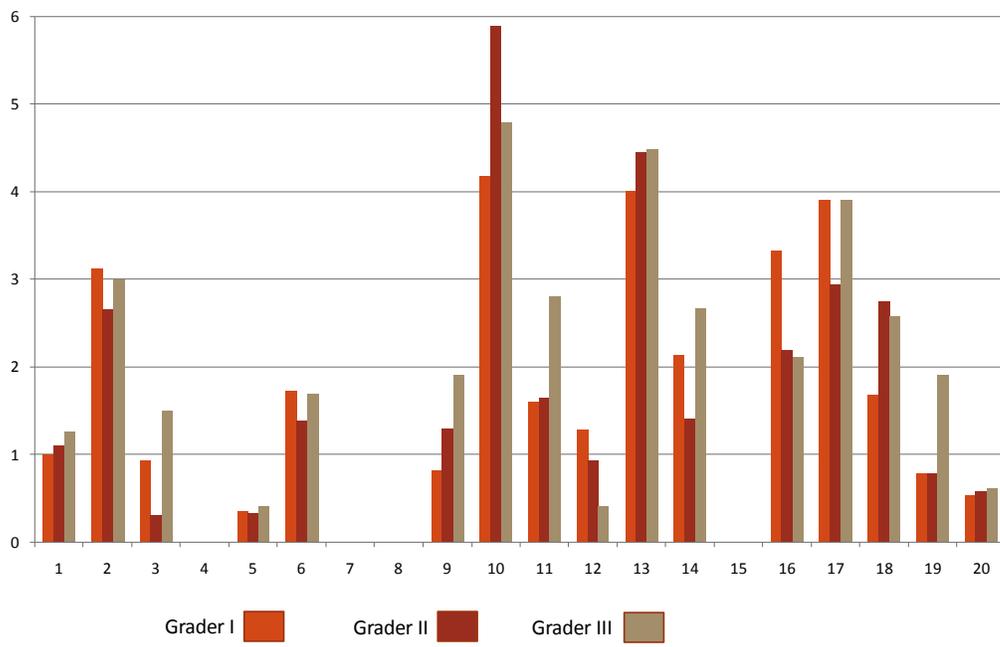


Figure 5- Group C- Dye Penetration by Grader

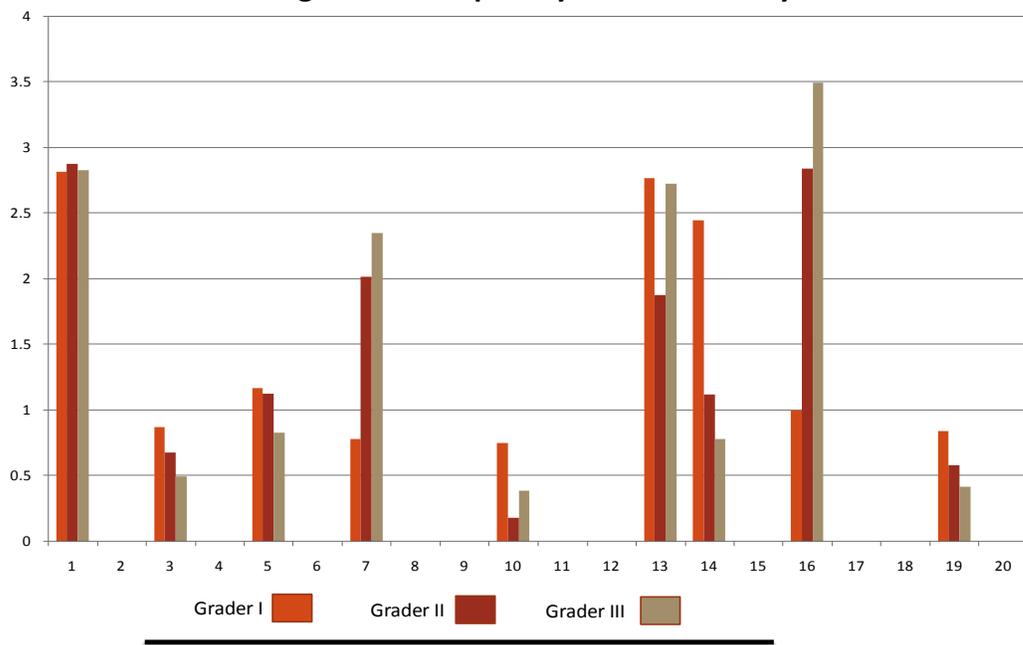
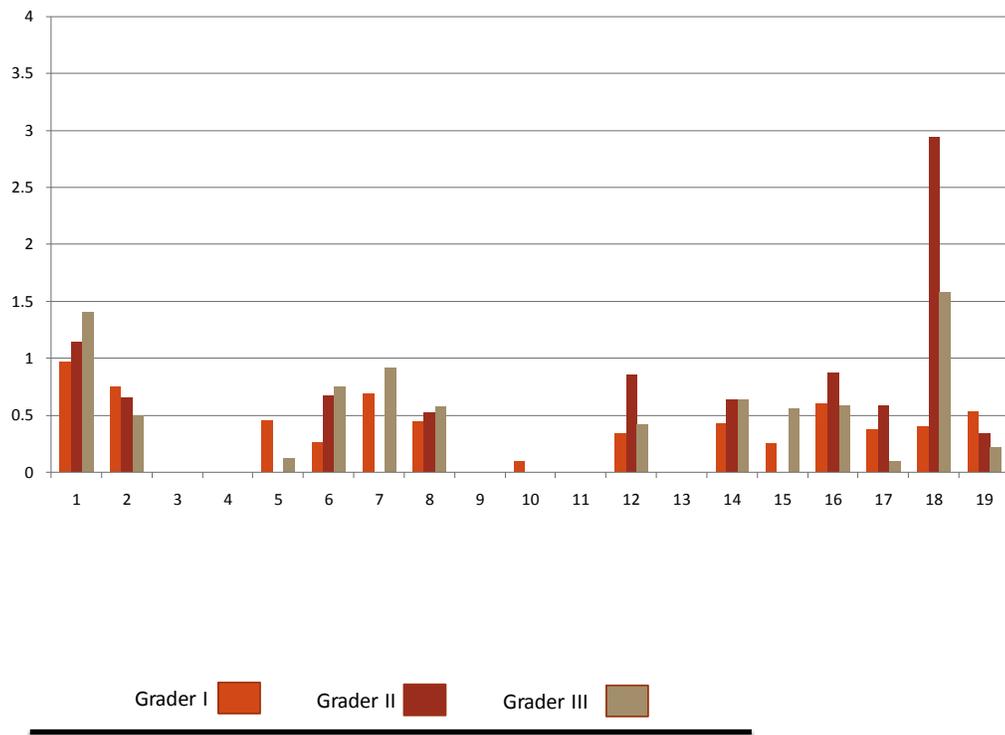


Figure 6- Group D- Dye Penetration by Grader



DISCUSSION

In vitro dye leakage studies have been criticized because mean leakage values are derived from a range of measurements with results and conclusions frequently inconsistent between studies. Differences may be attributed to variations in specimens, testing procedures, instrumentation/obturation techniques and leakage interpretations. One advantage of in vitro testing is that it provides a reasonable method for technique examination and observation without the many restrictions found in a clinical setting. Conversely, it is difficult, if not impossible, for in vitro studies to reproduce clinical conditions. Conclusive evidence regarding efficacy should be drawn from many studies conducted by independent investigators looking at similar technique aspects and from history of clinical use.

The present study was designed to evaluate in vitro apical leakage in root canals prepared in the identical manner utilizing two different sealers (AH Plus, iRoot SP) and two different obturation techniques (Single Cone, Lateral Condensation). Comparable levels of apical leakage were found between iRoot SP (single cone and lateral compaction) and AH plus single cone. AH plus with lateral compaction had statistically more apical dye leakage than the other groups. None of the negative controls showed any leakage and all of the positive controls demonstrated leakage supporting the experimental design.

Prepared root canals are by conventional standards, filled with a solid core material in the presence of an endodontic sealer. The long-term seal provided by such root fillings has been considered to be essential to clinical success. Sealers can fill in fins, apical deltas, and lateral canals, thus improving the sealing ability of gutta percha (71). Unfortunately, all sealers

suffer physical short-comings such as shrinkage and solubility. These undesirable characteristics are incompatible with long-term sealing efficacy. If dissolution occurs either at the interface between the gutta-percha and the dentin or between the individual gutta percha points, leakage is possible in the space previously occupied by sealer (72). The objective of obturation is to minimize the amount of sealer thickness while maximizing the amount of gutta-percha occupying the canal. Gordon et al (33) reported a similar percentage of gutta-percha filled areas when they filled curved canals first using .06 tapered rotary instrumentation followed by either SC or LC techniques. Horsted-Bindslev et al. (73) reported that the LC technique did not differ from the SC technique regarding the radiographic quality of the root fillings. Wu et al. reported the LC and SC in small curved canals had the same radiographic density and fluid transport measurements (74). Tasdemir et al. (75) found that the SC technique produced a significantly greater percentage of gutta-percha-filled area than LC technique at the 2mm from apex , but there was no significant difference 4mm from the apex with either technique.

AH plus was used in this study as the control sealer because of its known low solubility. Schafer and Zandbiglari, (76) compared the solubility of resin-, silicone-, calcium hydroxide-, zinc oxide- eugenol-, and glass ionomer-based sealers in water and artificial saliva, and reported that AH Plus lost the least amount of weight of all sealers tested in all liquids. Nagas et al (77) suggested that AH Plus may be preferable to EndoRez and Ketac- Endo regarding improved sealing and bonding of the obturation. Both of those studies concluded that the type of sealer can influence the quality of obturation.

Recently, single cone obturation methods that match the geometry of rotary instruments have been marketed for obturation of the prepared root canal. Use of a single cone can accelerate the obturation process, and at the same time, decrease the lateral forces on the root and possibly decrease the chance of iatrogenic vertical root fracture (78). The single cone with sealer combination results in a uniform mass which avoids the gaps associated with placement of several accessory cones in the LC technique(78). Gutta-percha cones and corresponding rotary instruments must be well matched for an optimal adaptation.

Some studies have concluded that SC suffers higher levels of apical leakage when compared to WVC, LC, and Thermafil techniques. Pommel and Camps (79) compared SC, LC, WVC, Thermafil, and System B techniques with a zinc oxide-eugenol-based sealer and reported that the SC technique had the most leakage. Monticelli et al. (80) compared two contemporary SC techniques with the WVC technique and found the WVC had a more durable apical seal. Yucel and Ciftci (81) concluded that the poor seal with SC may be related to the technique itself, because the gutta-percha is not compacted but it is only inserted to the working length with a substantial amount of sealer.

In contrast, Wu et al. (82) studied the leakage of single cone fillings using a silicone-based sealer for 1 year and concluded that SC fillings prevented fluid transport for that period. Antonopoulos et al. (83) and Yilmaz et al. (84) compared apical leakage in root canals filled with LC and SC technique and reported no difference between the two. Inan et al (85) compared the apical sealing ability of SC, LC, and Thermafil techniques and also found no difference.

The experimental group studied using the currently accepted technique of LC and AH Plus® was the only group that demonstrated statistically significant more apical dye penetration. This was in direct contrast to the studies performed by Onay et al. (86) and Raina et al. (87) which compared LC of gutta percha and AH Plus against LC of resilon and epiphany and found no significant difference in apical leakage in the experimental groups.

All groups included in the present study were obturated together and group C (AH Plus® with LC) was the last group to be instrumented and obturated. A better approach may have been to randomly assign all specimens so that treatment times varied within groups. This may have reduced operator fatigue which could have adversely affected results.

CHAPTER V

CONCLUSION

The presents study indicated that single cone obturation with either iRoot SP® or AH Plus® have equal or better prevention of apical dye penetration than lateral condensation with the same sealers. Although the clinician should examine many studies and rely on clinically proven methods before choosing one technique or material over another, it seems logical to place value in a technique or material which has been shown to provide a good apical seal in-vitro. Further studies may be necessary to evaluate the in-vivo success of cases which have been obturated in this manner. Also, of prime consideration, it must be remembered that Trope and Swartz concluded that the quality of the coronal seal is equally important to the outcome of endodontic therapy as the apical seal. The apical seal may be a temporary barrier to invading microorganisms being introduced into the periapex since sealers commonly used can dissolve over time. Regardless of which obturation technique is employed, the coronal seal must maintain a seal against invading microorganisms into the root canal that was disinfected during endodontic therapy.

All groups tested had similar apical sealing abilities, with the exception being AH Plus® LC group which demonstrated the most apical dye penetration. This in vitro study supports the use of the sealers AH Plus® or iRoot SP® in combination with .06 taper gutta percha points in the obturation of .06 canal preparations.

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