An In-vitro Evaluation of Apical Seal Ability of Thermafil Obturation Versus Lateral Condensation

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Statement of Problem: When a tooth is treated endodontically, there are several objectives, which must be met for the root canal therapy to be successful. One of those objectives is the complete obturation of the root canal system.

Purpose: The purpose of this study was to evaluate the apical sealability of the Theramfil endodontic obturation technique and compared it with lateral condensation.

Materials and Methods: Thirty human maxillary permanent anterior teeth were similarly prepared. Following instrumentation, the roots randomly divided into two experimental groups of ten and two control groups (positive and negative) of five each. Ten roots were obturated with Thermafil and ten with lateral condensation. All immersed in Indian ink, then cleared and apical dye penetration was evaluated.

Results: Average leakage values were minimum of 1mm to maximum of 2.9mm for lateral condensation and minimum 2mm to maximum 6mm for Thermafil group. There was statistically significant difference between Lateral Condensation and Thermafil obturation techniques ($P<0.05$).

Conclusion: The results of this study indicate that root canals treated by lateral condensation technique leak less than Thermafil ones.

Key Words: Apical seal; Thermafil; Lateral condensation

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When a tooth is treated endodontically, there are several objectives, which must be met for the root canal therapy to be successful. One of these objectives is the complete obturation of the root canal system.

Total obliteration of the canal and perfect sealing of the apical foramen at the dentino-cemental junction and accessory canals at locations other than the root apex with an inert, dimensionally stable and biologically compatible material are the goals for stability of successful endodontic treatments. (1)

According to the literature, many studies concerning to the preparation and obturation of root canal indicate that most filling materials do not completely fill the root canal system.(1-3)

Dow and Ingle(2) have revealed incomplete obliteration of the canal space to be the major cause of endodontic failure. It has been determined that approximately 60% of endodontic failures are due to inadequate obturation of the root canal system. (3) Many different obturation techniques have been introduced specifically to increase the quality of the apical seal.

Lateral condensation (LC) of gutta-percha has been proven to be a very popular and clinically effective filling technique. Schilder reported that final filling by

lateral condensation resulted in a non-homogeneous mass of many separate gutta-percha cones pressed together and joined only by friction and the cementing substance. He preferred heat-softened techniques. [4]

A variety of root canal obturation utilizing thermoplasticized gutta-percha or heat-induced compaction of gutta-percha has been evaluated.[5,6] These techniques have been designed to produce a more homogeneous canal seal, but conflicting conclusions were reported.

A method for carrying thermoplasticized gutta-percha in to the canal space described by Johnson in 1978.[7] Johnson claimed that the technique was effective in filling all canal spaces and Isthmuses. This system uses a central carrier (stainless steel, titanium or plastic) sized and tapered to match standard endodontic file, coated with a layer of alpha-phase gutta-percha. When heated, the hard alpha-phase gutta-percha thermoplasticizes and become suitable for canal obturation. The shaft of the file notched with a disk, it is forced to its working length, and, while apical pressure is applied, is twisted or bend back and forth until it breaks at the notch. The technique described as a single penetration, compacted, warm gutta-percha technique.

Recently, this method of obturation commercialized under the name of Thermafil (TF) endodontic obturators (Tulsa dental Products, Tulsa, UK) and added to the numerous root canals obturation techniques.

According to manufacturer, the advantage of the technique is that it completely fills a root canal, including lateral fissures, with single insertion, and maintains excellent apical control. [8]

A search of the literature revealed studies that compared apical seal quality produced by LC and TF obturators with metal carrier, which heated over an open flame.[9-21]

In these studies, teeth often were suspended in methylene blue or Indian ink, and apical dye penetration was measured after the root had been split or after the tooth had been cleared.

In several studies, TF obturation showed more apical microleakage, compared to LC.[9,11,13- 15]

In other articles TF obturators, showed reduction in micro leakage compared to LC.[10,12, 21] There are also investigations that do not show statistically significant differences in apical leakage between LC and TF. [16- 20]

Therefore the purpose of this study was to evaluate the apical seal ability of teeth obturated with Thermafil endodontic obturation technique and compared them with an equal number of teeth prepared and obturated with lateral condensation technique. The quality of seal was determined by the distance of penetration of Indian ink dye into the canal of extracted human teeth.

Materials and Methods

Thirty human maxillary permanent anterior teeth were selected from a collection of freshly extracted teeth. The teeth were stored in 0.9% isotonic saline at room temperature at all times. Specimens were soaked in 5.25% sodium hypochlorite solution for 30 min and the remaining periodontal tissue and calculus were removed. The teeth were radiographed from both buccolingual and mesiodistal aspects. Those that possessing calcified canals, extra canal, or resorption were not used in the study. To facilitate instrumentation, the crown portion of each tooth was removed using a fissure bur. To eliminate the root length as a variable, only teeth with roots 12 to 15 mm long were used.

Working length was determined by placing a #15 K file until it was just seen penetrating the foramen, after which 0.5 mm was subtracted form this and the length recorded. The canals cleaned and shaped with K files to a #45 file at working length. Irrigation with 5.25% sodium hypochlorite solution was performed using a 22-gauge needle during the instrumentation

process. The apical third of the canal flared using a step-back technique, while the coronal portion shaped using #2 and #3 Gates Glidden drills. (Union Broach) After complete cleaning and

shaping a #25 file used to establish apical patency. K-files and Gates Glidden drills were replaced by new ones after preparation of five canals. Following instrumentation, the teeth were randomly assigned to two experimental groups of ten each, a positive control group of five teeth and a negative control group of five teeth. The teeth placed in individually labeled vials filled with 0.9% isotonic saline solution.

Canal Obturation: The canals in the negative control group obturated with gutta-percha and root canal sealer. The canals in the positive group instrumented but not filled to show that dye was capable of penetrating the length of the canal. The canals of experimental group one were filled by the LC technique using standardized gutta-percha as master cone and Roth's root canal sealer (Roth drug company, Chicago, Ill) and #20 gutta-percha as accessory cones.

The sealers were mixed according to the manufacture's instruction. After application of sealer to the surface of prepared roots, the pre fitted master cone seated and a D-11 spreader was used to penetrate within 2 to 3 mm of working length to create space for insertion of a #20 accessory cone. LC continued using the same spreader and accessory cones until the canal was filled completely. Excess of gutta-percha was removed from the coronal part of canal with a heated instrument.

Following gutta-percha condensation with root canal pluggers, the coronal part of the canal filled with Cavit. (Premier Dental Products, Norristown, Pa.) All obturated root canals, were radiographed buccolingually and mesiodistally to determine the density of root canal fillings.

The roots in experimental group II individually obturated as specified by Thermafil manufacturer instruction. (Tulsa Dental products, Tulsa, UK) and Roth's root canal sealer. A TF device of the same size as the master apical file was selected. After application of root canal sealer to the walls of each prepared canal, the rubber stop adjusted on the TF device to the working distance. Then the gutta-percha portion of the TF device was heated over an open flame using a rotating motion to ensure uniform heating until the gutta-percha began to expand and became plasticized. The TF device then inserted to the working length with a firm apical pressure. By using an inverted bur, the shaft of the device then severed. After removal of excess gutta-percha the orifice of the canals filled with Cavit. All roots (experimental and control) were wrapped in wet gauze and placed in their vials for 48 hours, for complete setting of the cement. In some canals, the sealer and gutta-percha extruded through the apex during canal obturation.

Leakage measurement: Each root was dried with compressed air and its external surface was coated with two layers of nail polish except for an area approximately 2mm surrounding the apical foramen. The entire root surfaces of the negative controls coated with two layers of nail polish, to show that nail polish was capable of preventing dye penetration.

The roots were suspended in black Indian ink (Higgins) for 72 hours in their vials. Then they rinsed under running tap water, to remove the excess dye. After removing the nail polish with acetone, the teeth decalcified and cleared according to the method described by Robertson and associates [22] in the following manner.

The specimens placed for three days in 5% nitric acid at room temperature. The nitric acid solution was changed daily and agitated by hand three times each day. Decalcification was considered complete when the roots were soft and the radiographs showed no signs of calcified tissue. The decalcified roots rinsed in running tap water for four hours, and dehydrated in a series of alcohol tissue.

The dehydration process consisted of a series of ethyl alcohol rinses starting with 80% ethyl alcohol over night, followed by a 90% solution for an hour, 95% solution for an hour, and three 100% ethyl alcohol rinses for an hour each.

The dehydrated roots placed in methyl-salicylate (Sigma Chemical Co., St. Louis, Mo) for three hours, which made them transparent. The samples placed in individual labeled test tubes containing the

clearing solution.

The roots in the positive group were grooved and splinted longitudinally and examined to ensure that the ink was penetrated the length of the canals. To determine the amount of linear dye penetration, from the apex of the root to the most coronal evidence of dye penetration a dissecting microscope, equipped with a measuring device located in the eyepiece was used. Blind measurement of dye leakage was not possible because the metal carrier showed through the filling. Two examiners measured the amount of linear dye penetration. The mean of the two measurements was recorded for each case. The means and standard deviations for each group were determined. A nonparametric test was used to determine statistical differences between the two experimental groups.

Results

All control teeth performed as expected. The negative control group demonstrated no dye penetration. (Fig 1) The instrumented but not obturated positive control group showed ink penetration throughout the entire of the canal. Samples from the experimental groups (LC, TF technique) are demonstrated in Figure 1. The statistical calculations of linear dye penetration of both experimental groups are presented in table I. The values for linear leakage in roots obturated with lateral condensation technique ranged from a minimum of 1mm to a maximum of 2.9 mm (Fig 2).

The values for roots filled by the TF group ranged from 2 to 6 mm (Fig. 3). The teeth obturated with the TF technique leaked more than teeth filled with lateral condensation technique. A Mann-Whitney test ($P<0.05$) revealed that there was statistically significant difference between the apical dye penetration in canals filled by TF technique and those by the lateral condensation technique. ($P= 0.0126$)

During obturation with the TF technique, sealer and gutta-percha were extruded through the apex in some roots; this was an observation that was not found in the lateral condensation group.

Discussion

Single-rooted teeth with single patent root canals were selected, to minimize anatomical variation and allow standardization.

The method of examining cleared teeth for ink penetration under a dissecting microscope proved to be a good model for studying dye leakage in three dimensions. The pattern of leakage around the tooth was observed by rotating the tooth under the dissecting microscope, which only the maximum length of dye penetration was recorded. The high contrast between the black India ink and pink gutta-percha material made the leakage pattern quite visible and linear penetration was easy to measure with micrometer eyepiece. Ravanshad and Torabinejad have shown the particles of methylene blue dissolve during decalcification and clearing whereas Indian ink particles is stable.[23] The Indian ink was unaffected by the decalcification and clearing process.

The fact that extensive ink penetration was demonstrated in the positive control group and no leakage was observed in the negative control group indicates the validity of the experimental design to demonstrate leakage around the gutta-percha into the canal system.

Table 1- Mean and standard deviations of apical leakage in experimental groups. (Liner leakage values in mm)

Methods of obturation	Number of Specimens	Mean leakage	Standard deviation	Max. leakage	Min. leakage	Standard error
Lateral condensation	10	1.95	0.599	2.9	1.0	0.189
Thermafil	10	3.55	1.476	6.0	2.0	0.466

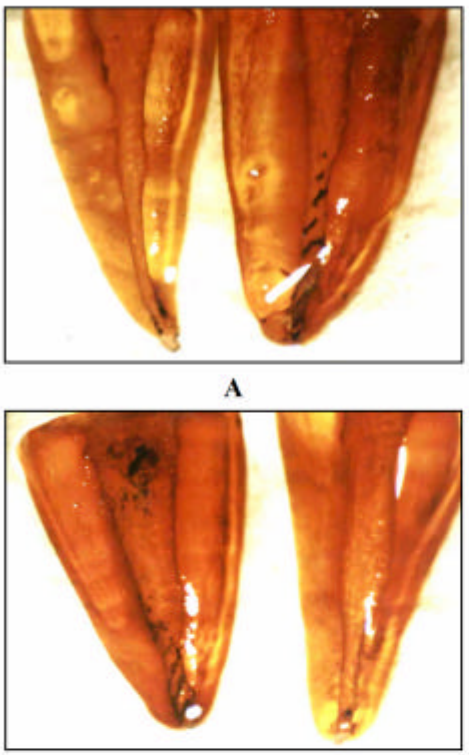

Fig. 1- Representative samples of both experimental groups. (Lateral condensation and Thermafil)

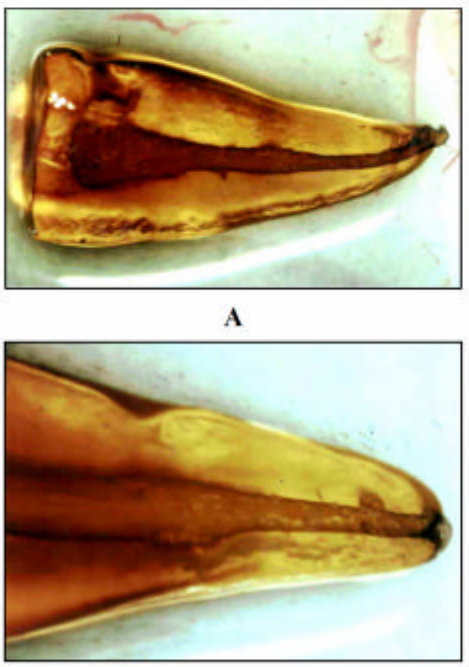

Fig. 2- Cleared specimen filled with lateral condensation shows trace of dye at the apical termination.
Note: the obturated lateral canal

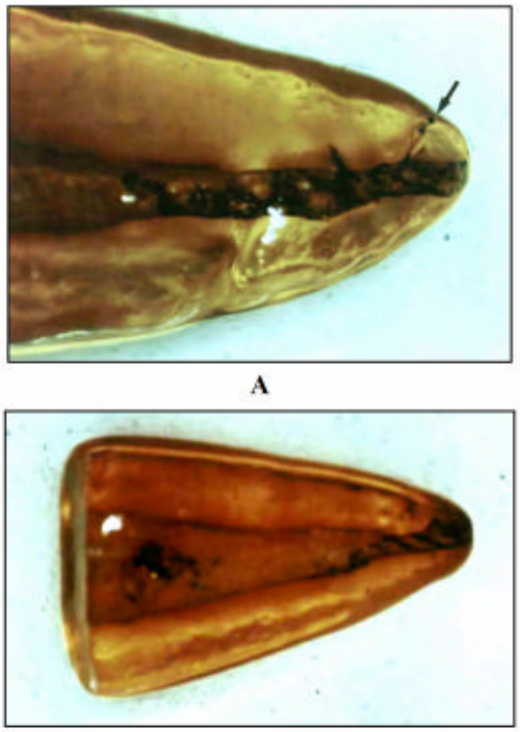

Fig. 3- Cleared specimen filled with Thermafil showing spiral pattern of dye penetration along flutes of metal core and interface between filling materials and dentinal walls. Arrow shows unobturated lateral canal, which is penetrated by dye.

The need for a good apical seal is not at question. A good apical seal is always the ultimate goal of root canal treatment. Zakariasen and Beatty state that although the exact importance of leakage was not known, until it is known, it would seem prudent to use techniques that provide the most effective seal. [24]

In this study, root canals obturated with the TF technique leaked more than those obturated with LC, which is in agreement with the result obtained by several studies [9, 11, 13-15].

In some of these studies, additional variables were evaluated too.

Lares and Eldeeb evaluated the quality of TF obturation on canine and molar teeth; step-back filling was used throughout instrumentation. Their finding showed that the difference in linear dye penetration between groups was significant in canines. In contrast, the differences in leakage

in molars were not significant. [15]

In addition, the result of present study is in agreement with the study done by Hata et al.[14] They found that the mean linear dye penetration for the TF technique was greater than that for LC and a significant difference was present. Barkins and Montgomery[9] compared seals produced by LC and TF metal obturators in curved canals prepared by the canal master–U system. Their finding showed greater leakage with TF than LC which was statistically significant, and exposed metal carrier was noted. Haddix et al [15] found significantly greater apical leakage associated with TF regular metal and twist off metal obturators, compared to LC that corroborate with findings of the current study.

In a study by McMurtrey et al [16] showed TF and LC to be equivalent in highly curved canals. Scott et al [17] found no statistically significant difference between amount of leakage in either obturation method or in the total time to complete root canal filling process.

The result of Julin and Walton study [25] shows that Thermafil components (carrier, gutta-percha, sealer) were variable in adaptation to each other and to the canal walls. Complete encasement of the carrier did not occur in any specimen, at the most apical extent.

The findings could suggest a possible mass shrinkage of gutta-percha after it cools down, which creates a gap between the gutta-percha and the canal wall leading to increase dye penetration. This could be the disadvantage of TF. In comparison to other warm gutta-percha techniques, TF is the only technique that does not employ condensation (compaction) while the gutta-percha is cooling down. Root canal filling material was compressed with the use of spreader in LC.

The advantages of TF technique are the short time required to fill the canal, the absence of the necessity for manual condensation, and the flowing characteristics of the thermoplasticized alpha-phase gutta-percha to replicate the canal wall.

The result of the present study is in contrast to the results of Beatty et al [10], whose finding showed TF and ultrafil were more effective in restricting apical dye penetration that laterally condensed gutta-percha or single cone techniques in straight canals. Differences in result between them could be related to variations in specimens, testing procedures and operator skills. In Beatty etal study, 1% methylene blue was used as a tracer, and the extent of dye penetration was measured after splitting the roots longitudinally. By comparison, in this study, Indian ink was used and linear dye penetration measurement was done after clearing technique. Clark and ElDeeb [20] in their study, which presented at 48th. Annual session of AAE April 1991 compared sealing ability of metal versus plastic carrier Thermafil obturators. They observed apical extrusion of gutta-percha in 75% and 85% of canals obturated with metal carrier Thermafil (MT) and plastic carrier Thermafil (PT) respectively. There was no significant leakage found in canals obturated with MT, PT and LC.

In the study presented here, extrusions of material were observed. Scott and Vire [26] using TF technique, demonstrated significantly greater problems with over-extension of material than that occur with other thermoplasticized gutta-percha techniques when foramen patency was maintained. Greatest concern remains with the potential for overextension of materials. The significance of sealer and gutta-percha extrusion through the apex that was observed during obturation with the TF technique needs further investigation, and indicated that this phenomenon should be controlled. Over filled root-fillings are considered undesirable by most researchers due to the potential for increased postoperative inflammation and delayed healing. Extrusion of filling materials could also be a factor that would clinically increase pain levels during and after obturation with Thermafil. Future studies on the use of Thermafil should evaluate its clinical effectiveness.

Conclusions

Based on the results of present studies it appears that:

a. Thermafil technique showed tremendous amount of dye penetration, due to probable mass shrinkage of gutta-percha after it cools down.
b. Lateral condensation technique produce better apical seal than Thermafil technique.
c. Extrusion of sealer and gutta-percha during obturation, indicate that this phenomena is a disadvantage for the method of obturation.

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