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Evaluation the effect of different instrumentation and obturation techniques on apical microleakage . (In vitro comparative study)

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Abstract

This in vitro study evaluated and compared the apical sealing ability of two obturation techniques and two type of instrumentation. A total of 120 teeth were collected randomly divided into two groups 60 roots prepared using hand protaper, other 60 roots prepared using rotary protaper .Each group was subdivided randomly into two obturation groups of 30 roots for each; in group A- obtura II was used ,and in group B-thermafill (TF) was used. Then the samples in all groups left for a week at room temperature. After coronal sealing, all surfaces of the root covered with three layer of nail polish except the apical 2mm, then each sample immersed in 10% black Indian ink dye for 72 hours .After that the samples rinsed and nail polish removed .then samples cleared & decalcified.Data had been collected from independent examiners and statistically analyzed using student t-test. The stereomicroscopic results showed that there was highly significant difference between hand and rotary instrumentation, with in favor of rotary instrumentation technique. Concerning the obturation techniques, Thermafill showed best apical sealing followed by Obtura II; however, the differences were not significant.

Key word: Instrumentation,obturation,apical seal,apical microleakage.

Introduction

It is believed that the most unsuccessful cases of root canal treatment are caused by apical leakage which is entering of fluid from inflamed periapical tissue into improperly obturated canals [1].

The quality of apical seal obtained by root end filling materials has been assessed by the degree of microleakage that can be measured by dye penetration, radioisotope penetration, bacterial penetration, electro chemical means and fluid filtration techniques. All of these techniques have been shown to have a variety of shortcomings. The dye penetration method used for measuring sealing ability is the most popular and is easily performed. Various dyes that can be used include India ink, basic fuchsine, silver nitrate with developer and methylene blue [2].

The preparation of root canal system is essential for successful outcome in root canal treatment, the mechanical debridement of root canal is meant to eliminate vital and necrotic tissue from the root canal system, along with removal of infected dentin[3]. A three dimensional well-fitted root

canal filling prevents percolation and micro leakage of peri-apical exudates into the root canal space, prevents re-infection and creates a favorable biological environment for healing to take place. Advances in technology have led to development and implementation of many gutta-percha obturating systems, a variety of root canal obturation utilizing thermoplasticized gutta-percha. Recently, this method of obturation commercialized under the name of Thermafil (TF) endodontic obturators [4]. Another one is Obtura II, which is a thermo-plasticized injectable obturation technique introduced to improve the homogeneity and surface adaptation of the gutta-percha instrumentation and obturation techniques on apical microleakage[5].

The aims of this study was to evaluate the efficacy of two different instrumentation and obturation techniques on apical microleakage.

Materials and methods

Sample selection

One hindered twenty human teeth used in this study which were permanent premolars that have single canal &distal root of lower permanent first & second molar & palatal root of upper permanent first & second molar. Teeth were selected from a collection of freshly extracted teeth, the age, gender, pulpal status and reason of extraction were not considered. The teeth were scaled by hand scalar and washed with distill water for removal of any calculus and soft tissue debris, teeth were stored in 0.9% isotonic saline at room temperature at all times. Specimens was soaked in 5.25% sodium hypochlorite solution before using for 30 min for cleaning any remaining periodontal tissue and calculus .The roots that had been selected for this experiment have certain criteria that each root had single canal with specified diameter of the apical terminus(size #15 is the first file that bind to the working length) .The roots should be straight & the roots should be sound not carious ,but if the roots cracked , fractured, or have resorption when examined under magnifying eye lens(X10) had been discarded ,the roots length were not less than 12 mm from apex up to cement-enamel junction .

Sample preparation.

To facilitate instrumentation, the crown portion of each tooth had been removed at CEJ using high speed hand piece(turbine) of cutting diamond fissure bur with water coolant so that working length standardized to 12mm for eliminating root length as variable .

After de-coronation only roots with single canal were chosen. Stain less steel K file size 15 had been used to verify the canal patency in combination with initial irrigation with 5.25%prepared NaOCl solution. (1ml via disposable syringe) the Stain less steel K file (size #15) must reach the apical terminus & appear from the root apex slightly &tightly (just seen) any root that was not fulfill this criterion had been discarded & not involved in this study. After that the working length was calculated using stainless steel K file (size 15) by methods consists from permitting the stainless steel K file 1 mm short from apex. Then the samples stored in isotonic saline in their vials that was coded by bounding plasters around each vials.Fig. (1).

Sample grouping

The selected roots one hundered twenty in number were divided randomly into 2 groups,

- Group A:Roots instrumented with hand protaper (60 roots)

- Group B: Roots instrumented with rotary protaper (60 roots)

Then each group was subdivided into two subgroups randomly:

1. Roots obturated by injectable thermo-plasticized gutta-percha technique, obtura II (30 roots).
2. Roots obturated by solid core carrier insertion of thermo plasticized gutta-percha, thermafill (30 roots).

Instrumentation techniques:

Manual instrumentation (hand protaper)

Gates Glidden drill size no(1,2,3and 4) were used for orifice widening each of them for 3 seconds,explore the canal patency by Stainless steel K file(size #15)must reach the apical terminus & appear from the root apex slightly &tightly after that the working length was measured and confirmed by subtracting 1 mm of the file size #15 from the apex .

Instrumentation started with S1,S2 (shaping files) ,first S1used for coronal 2/3flaring (7.5 mm) of the canal which used by gently rotating the handle clockwise until the file just snug, disengage the file by rotating the handle counter clock wise about 45-90 degrees. the dentin had been cutted by rotating the handle clockwise while simultaneously withdrawing the file ,repeat handle motions until desired length was achieved., then S2 used to coronal 2/3flaring of the canal ,f1 used to finishing full length (11mm) followed by f2,f3,f4(finishing files) until the files became loos. After each file the canal was irrigated with 0.2 ml of 17% EDTA for 1 min .combined with 1 ml of 5.25% prepared NaOCI [6]. Finally complete dryness had been executed with certain numbers of absorbent paper points(size#40) until dry points gained and checked on dental mirror.Correct instrumentation was checked by the presence of the apical stop to the full working length via the master apical file (k file size#40).

2.3.2 Rotary instrumentation

Before starting instrumentation the canal were irrigated with 1ml of 5.25%prepared NaOCI combined with 0.2 ml 0f 17% EDTA solution for one minute using a disposable syringe via 22- gauge needle., explore the canal patency by SS K file(size #15)must reach the apical terminus & appear from the root apex slightly &tightly .After that the working length was measured and confirmed by subtracting 1 mm of the file size #15 from the apex. [7].

Instrumentation started by S1which was used for enlarging coronal 2/3 of the canal, and irrigating solution was used for lubricating the canal and instrument and allows easy entrance of the file. S2 used to just 2-3 mm shorter than the estimated working length for each canal .finally the apical third was prepared by using f1,f2,f3and f4 files(finishing files) up to the full working length by just passing the file one time to the apical ears without excessive rotation of the file when its in the full working length. complete dryness had been executed with certain numbers of absorbent paper points(size#40) until dry points gained and checked on dental mirror correct instrumentation was checked by the presence of the apical stop to the full working length via the master apical file (k file size#40),

Obturation techniques:

Injectable thermo-plasticized technique:

After completion of instrumentation each canal was coated with a thin layer of sealer AH-26 that was mixed according to manufacturers

with the help of the size# 40 hand spreader.

Before obturation of the canals, the obtura II device had been prepared a gutta-percha pellets placed into the delivery gun which heated up to the desired temperature 190 **º C** (manufacture recommendation is from 185 **º C** to 200 **º C**) .after a few seconds, once the temperature was reached ,the gutta-percha was injected through a needle at a desired flow rate (manufacture recommendation is 60%) by hardly pressing on the gun . the needle was bent with finger for better canal access, however, finger pluggers (size#25,#35,#40) were prefitted inside the canal in such away they reached (to the coronal two thirds of the canal, to the coronal one third, to the coronal 2-3 mm from the orifice) respectively. With complete freedom & were used for compaction of gutta-percha piece vertically,then the sealer AH_26 was mixed according to manufacturer's instructions and a thin coat of the sealer applied to the internal wall of the canal with the aid of finger spreader size(#40), the canals were obturated by injecting of thermo - plasticized gutta-percha mass using obtura II device via obtura II needle which was inserted into the canals in three steps(apical third, middle third, coronal third) ,as gutta-percha was injected , the tip felt raised, at this point, the hand was stopped from pressure to stop gutta-percha injection, the tip was removed from the canal as soon as possible, cold finger pluggers (size#25,#35,#40) were introduced inside the canals in such away they reached (to the coronal two thirds of the canal, to the coronal one third, to the coronal 2-3 mm from the orifice respectively). Pluggers are used to compact of gutta-percha mass vertically in apical, middle, and coronal part of the canal respectively, in an apical direction with sustained pressure until apical resistance to the compaction pressure was felt& were compacted later on vertically using heated endodontic plugger that dipped in sealer so that the gutta-percha not attached to the plugger. The technique was considered complete when canal orifice completely filled the obturated samples stored in wrapped gauze with normal saline at room temperature.

Solid core carrier insertion of thermo-plasticized gutta-percha:

After completion of instrumentation, a according to the working length which is 11 mm the shaft of the TF obturators was notched by blade of scalple. Then each canal was coated with a thin layer of AH-26 sealer with the help of the size# 40 hand spreader. Therma-prep oven was pre heated before obturators are heated, then size 40 TF obturator was placed in the Therma-prep oven 30-60 timer selected & start pressed to start heating According to manufacture instructions a timer was used to ensure correct heating time for each size of gutta-percha.

After removing the obturator from the oven, firm apical pressure was used to insert the TF obturator into the canal to the previously marked working length. Then carrier shaft was severed with inverted cone bur at the canal orifice.A small condenser lubricated with Vaseline was used to condense vertically the gutta -percha around the shaft.

Dye penetration study

For each root the coronal 2mm of gutta-percha was removed by hot ash no.49 and sealed with a temporary fillings, which placed in the orifice opening by hand plugger to preclude any dye solution that may enter coronally ,the apical 2mm of each root was measured by digital calliper and marked by a marker ,with the exception of this 2mm the rest of root

surfaces was covered by three layers nail polish, After that 10% Indian ink dye was added to each vials that was coded and each of them contain one root .The samples were left at room temperature for 72 hours, (fig 2), to allow the dye to enter into unfilled spaces of the canal. During this period the each vials has been shacked every 6 hours to allow all surfaces of the root to be available to the dye solution.

Decalcification step

After this period, the roots were washed under running tap water and the nail polish was removed from the surface of the roots by acetone and excavator and then dried under compressed air, after drying of vials again the roots placed in their vials. After that, the teeth decalcified and cleared according to the method described by [8] in the following manner. Decalcification of roots had been done by using 5% nitric acid which was prepared by adding 5ml of nitric acid to 95 ml of distilled water .Prepared nitric acid added to each vial, the vials had been agitated every 8 hr to allow all surfaces of roots become decalcified and nitric acid was changed daily for about 3 to 4 days .Roots had been checked to become decalcified ,sign of decalcification was (root become soft and head of sharp probe can penetrate the root) as described by [4].

Dehydration step

After this period the roots washed under running tap water for 4 hr ,(for cleaning the roots from nitric acid), Then the roots and vials has been dried and each root replaced to their vials, dehydration had been done by adding a series of alcoholic solution (ethyl alcohol). First 80% ethyl alcohol solution was prepared by adding 80ml of ethyl alcohol to 20 ml of distilled water, and then added to vials for overnight (12 hrs) after this time the solution in the vials was changed. The prepared 90% ethyl alcohol was added to samples and remaining in it for 1 hr, after this time the solution had been changed and the prepared 95% ethyl alcohol was added and the samples maintained in it for 1 hr finally 100% ethyl alcohol added to sample for 1 hr ,

Clearing step

After dehydration methyl-salicylate was added to samples ,after 3 hours the roots become transparent (the entire inner surface i.e. the gutta-percha could be seen by naked eye) fig (3) .The roots stored in the clearing solution till the time of examination under the stereomicroscope by using graded lens.

Stereomicroscopic examination:

The samples was examined under stereomicrospe (eye lens 10X, objective lens 6.4X) by specialist that's blinded to the groups, graded lens had been used for calibrating the dye penetration in which each line is 0.16 mm. the roots placed over the slide then examined from all surfaces by rotating the sample under stereomicroscope [4].

The highest point had been considered for measuring linear dye penetration .For obtaining the dye penetration measurements in millimeters the number of lines was multiplied by 0.16. fig (4).

The collected data were analyzed by using SPSS version 15 for windows, (SPSS, Chicago, Illinois, USA) which include calculating the means of apical leakage and Student t-test was used to compare between each corresponding pair of groups for each treatment.

Results

Stereomicroscope evaluation:Comparison between groups:

T-test was used for comparison between all subgroups G(1), G(2), G(3), G(4) and table (1) shows that Highest mean value was for G1 (hand,obtura II \)which is about 2.53millimeters ,and lowest mean value was for group 4 (rotary, thermafill) which's about 1.92 millimeters & the difference was non-significant.

Instrumentation technique:

Comparison between instrumentation techniques:

t-test was used for comparison between hand instrumentation and rotary instrumentation Table(2) shows that there is difference in the mean between hand and rotary instrumentation technique, hand instrumentation had higher mean value than rotary instrumentation and the difference was highly significant.

Obturation technique:

Comparison between obturation techniques:

T-test was used for comparison between obturaII and Thermafill obturation Table (3) shows that there is difference in the mean between obturaII and Thermafill obturation, obturaII had higher mean value than thermafill obturation and the difference was non-significant.

Discussion

Many different methods used for leakage assessment, dye penetration method, which first reported by Grossman in 1939, is most commonly used, [9; 10.]

The method of linear dye penetration include tooth immersion in dye that penetrates through any space present in the obturated canal, then the tooth sectioned longitudinally, transversely, or decalcified and cleared, and the linear dye penetration recorded. Deeper dye penetration suggested more micro-leakage.

In this study decalcification and clearing was used and preferred over the sectioning because 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 without destroying the root specimen but a major disadvantage of sectioning is the inability to measure leakage without damaging of root specimen**.** [11]**.** Traditional method of sectioning of the samples are associated with loss of some of the tooth structure due to thickness of cutting blade and the sectioning process, thus affecting the accuracy of the measurements of the dye penetration[12]**.**

The pattern of leakage around the tooth was observed by rotating the tooth under the dissecting microscope, in which only the maximum length of dye penetration was recorded. Black Indian ink was used in this study so the high contrast between the black India ink and gutta-percha material made the leakage pattern quite visible and linear penetration was easy to measure with micrometer eyepiece [4]**.**

The particles of methylene blue dissolve during decalcification and clearing whereas Indian ink particles are stable. The Indian ink was unaffected by the decalcification and clearing process. In addition methylene blue being difficult to observe its maximum penetration point in some cases [13].

Stereomicroscope evaluation:

Effect of the instrumentation technique:

The objective of instrumentation and irrigation is to promote cleaning and shaping of the root canals. These objectives can be achieved by mechanical, physical and chemical

means, which are used in combination during endodontic preparation in order to yield the desired results, while separate use does not lead to success. Therefore, varying results can be obtained according to the combination of irrigation regimens and instrumentation systems used**.**[14]

The results of the present study showed that groups prepared with rotary instrumentation technique showed better apical sealing after obturation than those prepared with hand instrumentation technique and the difference was highly significant.

Schafer and Zapke [15] Found that Complete cleanliness was not achieved by any of the techniques and devices (profile and K-Flexo file), but best instrumentation results were obtained with rotary Profile instruments**,** this study disagree with the present study because they showed that there is fair evidence to support the use of rotary instrumentation over manual hand files. Because was not able to find a significant difference between hand and rotary instrumentation. This disagreement may be due to differences between the type of instruments that was used.

Whereas Tan and Messer [16] found that there is a significant difference between hand and rotary instrumentation in the cleaning ability at the most apical regions of the tooth. In regards to shaping of root canals, stating that there is an advantage to the use of rotary instrumentation due to minimized canal straightening, canal transportation, and perforation. As a result decrease apical microleakage. And this study agrees with the present study.

Other researchers reported a significant difference in the maintenance of canal curvature as well as preparation time and shaping of canals when comparing rotary and hand instrumentation. The results were such that the rotary instrumentation was superior to hand instrumentation in shaping the canals ($p< 0.0001$) that agree with the present study.[17]

NiTi rotary instruments demonstrate superior quality of canal preparation with respect to canal cleaniness, canal transportation and canal shape. Not all the groups of NiTi rotary instruments could totally debride the apical portion of root canal however the protaper type of rotary instrument demonstrated a comparatively better quality of canal preparation in comparison to other groups [18]**, that's** why used in their study.

Effect of the obturation technique:

Cleaning and shaping is undoubtedly of paramount importance in successful endodontic treatment. However, this does not negate the importance of the quality of obturation. This is validated by the fact that nearly 60% of failures in endodontics can be attributed to incomplete obturation of the root canal. Hence, a three - dimensional obturation is critical for endodontic success**.** [19]

Irrespective of the obturation technique employed, micro leakage remains to be the most crucial cause of endodontic failure. Micro leakage is defined as the passage of bacteria, fluids, and chemical substances between the root structure and filling material of any type. This occurs because of microscopic gaps at the interface of the filling material and the tooth. Microleakage in the root canals is complicated as many variables may contribute, such as root filling technique and chemical properties of the sealer and the infectious state of the canal. [20]

In the present study ObturaII and TF were used, Obtura II group leaked more than the TF group .that agree with [5],and disagree with[7]**.**

Shrinkage of thermo-plasticized gutta-percha occurs during it's cooling to 37° C [21]**.** Alpha-phase gutta-percha which has low melting temperature and good adhesiveness, whereas beta-phase gutta-percha which has high melting point, and no properties of adhesion. This setting contraction has to be compensated by the sealant being employed [22]**.**

Thermafil obturators are flexible plastic carriers coated with alpha-phase gutta-percha while Obtura II contains beta phase gutta-percha. Hence, the potential for the shrinkage of the thermo-plasticized gutta-percha as used in TF is lesser than that of Obtura II. Moreover, in the TF system the majority of the canal space is filled with the plastic core there by reducing the volume of gutta-percha undergoing setting contraction. This reduction in shrinkage could have increased the seal at the gutta-percha- sealant interface, there by contributing to decreased leakage. This would have been one of the reasons for TF to leak less than the other thermo-plasticized technique assessed, namely Obtura II. The plastic carrier in TF could also act as plunger, which effectively forces the thermo-plasticized gutta-percha into the lateral walls of the canal. This condensation of the thermo-plasticized gutta-percha into the patent dentinal tubules might also have contributed to the superior seal exhibited by the TF group [5].

Conclusion

Under the circumstances of this in vitro study, the following conclusions were drawn:

1. Roots that prepared by protaper hand instrumentation had highest leakage value of dye penetration in comparison to rotary protaper instrumentation and the difference was highly significant .
2. Solid core carrier thermoplasticizised obturation (thermafill) had less dye penetration than injectable thermoplasticisized obturation (obtura II) with non significant difference.

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Fig(1) Sample coding

Fig: (2).dye penetration

Fig: (3) Cleared samples in methyl salcylates

Fig :(4) Stereomicroscope examination of cleared sample

Statistical analysis

Table 1: t-test for the obturation technique and instrumentation techniques

Steromicroscope		**No**	**Mean/mm**	**SD**	**t-test p-value**
G1	Hand Obtura II	15	±2.53	.484	0.59
G2	Hand Thermafill	15	±2.40	.438	0.59
G3	Rotary Obtura 2	15	±2.00	.368	0.43
G4	Rotary Thermafill	15	±1.92	.425	0.43

Table (2) t-test for difference between the instrumentation techniques .

Stereomicroscope		**No**	**Mean**	**SD**	**t-test P-value**	**Decision**
GI	Hand Instrumentation	30	3.3227	1.116	.000	HS
G2	Rotary Instrumenation	30	1.7227	.6473		

Table (3) t-test for the difference between obturaII and thermafill obturation.

stereomicroscope	**No**	**Mean**	**SD**	**t-test P-value**	**Decision**
Obtura2	30	2.6720	.804	.47700	**NS**
Thermafill	30	2.3733	.764		