Research Paper

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Assessment of the efficacy of three different techniques for removal of smear layer combined with the use of Apexit Plus Sealer in preventing apical dye penetration (in vitro study)

Medical Science

KEYWORDS : NaOCl, EDTA, Nd: YAG laser, Apexit plus sealer. Apical dye penetration

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ABSTRACT

objectives: *The purpose of this study is to evaluate the apical leakage of root canal sealers: (Apexit plus) in combination with three different techniques for removal of smear layer: (irrigation the instrumented root canal with 2.5% NaOCl alone, irrigation with 17% EDTA followed by 2.5% NaOCl, and application of Nd: YAG laser) by using apical dye penetration measurement.*

Method : *Thirty freshly extracted human teeth with single, sound root and straight one canal were collected. The step-back preparation technique of the roots canals instrumentation was performed with K-type files. Specimens were randomly divided into three groups (n=10) according to the techniques that used to remove the smear layer.*

Then the teeth obturated with root canal sealers (Apexit plus) and gutta percha using cold lateral condensation technique. All specimens immersed in 2% Methylene blue dye solution for 72 hours, after cleaning the root surface from the dye, all roots were sectioned longitudinally and the depth of dye penetration was measured by grid scale disc under a stereomicroscope.

Results : *The results showed that the lowest mean apical leakage was obtained by using (17% EDTA followed by 2.5% NaOCl), then by (Nd: YAG laser) treatment, while the highest mean leakage is obtained by (2.5% NaOCl alone).*

Conclusion: *The lowest mean apical leakage was obtained by using (17% EDTA followed by 2.5% NaOCl), while the highest mean leakage was obtained by (2.5% NaOCl alone),*

Introduction:

Endodontic smear layer is a thin tenacious layer of debris retained on the dentine surface after instrumentation with either rotary instruments or endodontic files, which consist of organic and inorganic materials. (Jacob et al. 2000). Several mechanical, chemical and ultrasonic techniques, as well as various types of lasers, have been utilized with the intention of removing the smear layer (Sulewski, 2000).

The most popular endodontic irrigant is sodium hypochlorite (NaOCl) at concentrations of 0.5% to 5.25%. The tissue-dissolving capacity and microbicidal activity of NaOCl make it an excellent irrigating solution, but it has only limited effect on the dissolution of smear layer (Zehnder et al. 2002).

Ethylenediaminetetraacetic acid (EDTA) is generally accepted as the most effective chelating agent with lubricant properties and is widely used in endodontic therapy. It is used to enlarge canals, remove the smear layer and prepare the dentinal walls for better adhesion of filling materials. The EDTA at 17% concentration is widely preferred for root canal treatment (Serper and Semra, 2002), (Parmar and Chhatariya . 2004).

The use of EDTA followed by NaOCl has produced the best results for smear layer removal (Yamada et al. 1983).

The use of the laser beam, especially Nd: YAG laser, in the dental field is well-known and has been investigated by numerous researchers. In endodontic applications, Nd: YAG laser seal dentinal tubules and remove debris and smear layer from instrumented root canals (Goya et al. 2000).

The endodontic sealer performs various functions during the obturation of root canal system: it lubricates the root canal and aids the sealing of the master gutta percha cone, acts as a binding agent between the gutta percha and the canal wall and fills anatomical spaces that the primary filling material has failed to reach (Mahajan and Kamra, 2007).

A great variety of endodontic sealers are available commercially, and they are divided into groups according to their chemical composition. They are based on zinc oxide and eugenol, resin, calcium hydroxide and glass ionomer (Cobankara et al. 2006).

Calcium hydroxide based sealer (e.g. Apexit plus) has a high pH, which creates a highly alkaline environment, where most bacteria are be killed and its biocompatibility is excellent with the formation of a cementum over the apical foramen (Noort, 2002), (Goldberg et al. 2008).

Materials and methods:

Thirty extracted human teeth with sound, single root with one canal were collected (discard any root that have not comply with criteria) and were mechanically cleaned with ultrasonic scaler to remove calculus and rubber cup and Pumice to remove surface soft tissue, and then stored in 50% ethanol at 8°C for a maximum of one month following extraction in order to avoid microbial contamination.

The crown of each tooth was sectioned at the cemento-enamel junction using a diamond disk with a straight handpiece with water cooling. The pulp in root canals of each root was removed with a barbed broach and the canal patency was determined by passing a size No 15 K-file through the apical foramen.

A size 15 file was inserted into the root canal until the tip became visible at the apical foramen; this distance minus 1 mm was taken as the working length.

Instrumentation of the root canals was performed with a step-back technique; apical portion of canals was prepared to size No. 40 K- file, while in the coronal third to size No. 60. The file was inserted, watch wound, and retracted followed by recapitulation and irrigation. This is followed by copious irrigation with 2ml of 2.5% NaOCl before the next instrument is introduced.

The specimens were randomly divided into three groups:
Group 1: ten root canals were irrigated with 2ml of 2.5% NaOCl alone for 5 seconds as a final irrigation of the instrumented root canals.

Then each canal was finally dried with paper points (size no.30...45), until the paper point was dry, then the patency of the apical foramen confirmed with a size No. 40- File.

Group 2: ten root canals were lased with an Nd: YAG laser system ("twinlight" laser, Fotona, Italy) with a wave length of 1046 nm, and following parameters: 15 Hz, 100 mJ and 1.5 W for 28 seconds. For lasing, a 35-like file optic fiber was used and helicoidal movements (helix movement on the wall of the root canal) in a crown-apical (to the working length) and vice-versa (from the apical to the crown) direction was applied.

Group 3: ten root canals were irrigated with 3ml of 17% EDTA solution for 30 seconds followed by 2ml of 2.5% NaOCl for 5 seconds, then each canal was finally dried with paper points (size no.30...45) until the paper point was dry, then the patency of the apical foramen confirmed with a size 40 File.

Obturation of the root canals: the root canals were filled with (Apexit plus) sealer and taper gutta-percha using the cold lateral condensation technique.

No manual mixing is required for mixing of Apexit plus sealer because it is supplied in double-push syringes with a static mixing device. The material is thoroughly mixed in the correct ratio as it is dispensed and can be applied immediately. The mixed material was picked up directly with lentulo spiral filler and spanned it into the canal. Its working time is approximately three hours and its setting time is between two and five hours.

An ISO size 40 master gutta-percha cone that was fitted and was gave tug-back at the working length, was chosen and was lightly coated with Apexit plus sealer and was placed into the canal to working length. A cold lateral condensation technique used until the entire root canal was obturated completely with gutta percha and no more space was permit to the entrance of the size no.15 spreader and auxiliary gutta percha that is mean complete obturation of the root canal. The excess gutta-percha was removed with a heated instrument (plugger) and then compacted vertically using a cold plugger.

Then coronal 1mm of the gutta percha was removed by a hot instrument (spoon excavator) and the entire dentin wall and the top surface of the root was acid-etched and bonded and filled with composite resin material. All samples were checked for complete perfect obturation radiographically.

All the specimens were stored in incubator for two weeks in 100% relative humidity at 37 °C to allow the sealers to set. Then all specimens were dried and coated with three layers of nail varnish leaving only the apical 2 mm exposed.

The obturated specimens were then stored in twelve tubes containing (2% methylene blue dye solution) at 37°C for 72 hours, then the tubes were shaken.

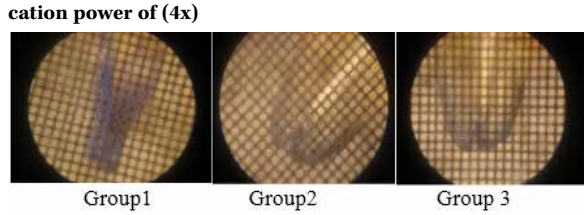
After removal of the specimens from the dye, they were washed with distilled water, dried and the nail varnish was removed with a scalpel.

The root of each tooth was sectioned longitudinally in a mesiodistal directionby diamond disc. The root was then carefully separated into two parts using a chisel. The gutta percha and filling materials were removed from the canals by a metal spatula.

The sectioned roots were examined by two examiner under a stereomicroscope (power 4 X), and the linear extent of maximum dye penetration was measured of each half of the sectioned roots of all groups, with an aid of a grid scale disc, which contains many cubes, each wall of any cubic equals to 0.25 mm as shown in figure(1). The average mean of the length of dye penetration of the two readings in the two halves represents the level of the extent of dye penetration.

Student t-test: is used to compare between each groups.

Figure1; The sectioned roots of the groups, under the stereomicroscope with an aid of a grid scale disc, with magnification power of (4x)



Result:
The instrumented root canals that were irrigated with 2.5% NaOCl alone gave the highest value of apical dye penetration; (1.397mm), followed by the group that applied with Nd: YAG Laser; (.652mm), while the group that irrigated with 17% EDTA followed by 2.5% NaOCl gave the lowest value of apical dye penetration; (.336mm). as shown in figure (2 and 3).

Table (2) shows that paired t-test when using Apexit plus sealer indicated statistical non-significant difference (P>0.05) between group1 (Irrigation with 2.5% NaOCl only) and group2 (Application of Nd: YAG Laser).

Between group1 (Irrigation with 2.5% NaOCl alone) and group3 (Irrigation with 17% EDTA followed by 2.5% NaOCl) there is highly statistical significant difference (P<0.01). But the difference between group2 (Application of Nd: YAG Laser) and group3 (Irrigation with 17% EDTA followed by 2.5% NaOCl) is not statistically significant (P>0.05).

Table 2. Student t-test to compare the apical dye penetration of three techniques group

Groups	Paired Differences					t-test	df	Sig.
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Group1-group2	.744	.7512	.2375	.2068	1.2816	3.133	9	N.S.
Group1- group3	1.060	.6276	.1984	.6117	1.5097	5.344	9	H.S.
Group2 – group3	.3165	.6020	.1903	-.1141	.7471	1.662	9	N.S.

Figure (2) the apical linear dye penetration of the three groups

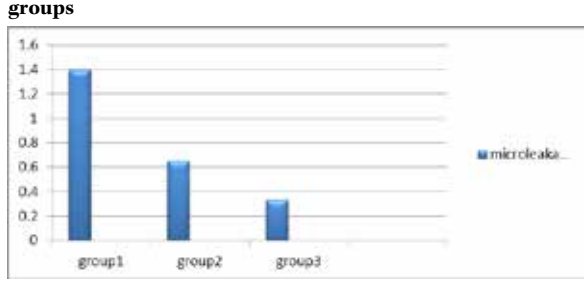


Figure (3) apical linear dye penetration of the all three groups

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Discussion:

Apical leakage is considered to be a common cause for endodontic therapy failure, and is influenced by many variables such as; instrumentation technique, the physical and chemical properties of sealers used, sealer thickness, different filling techniques, the presence or absence of a smear layer, type and concentration of chelating agents used, and the technique used to remove the smear layer (Wennberg and Orstavik, 1990), (Verissimo and Vale, 2006).

Current methods of smear layer removal include chemical, ultrasonic, and laser techniques, none of which are totally effective or have received universal acceptance (Torabinejad et al. 2002).

Many methods have been used to evaluate the sealing ability of filling materials, but the most common are dyes and radioactive isotopes. Among dyes, methylene blue dye is widely used for convenience and can provide a high degree of penetrability due to its small molecular weight (Ozata et al. 1999), (Farhad and Elahi, 2004).

The results of this study indicate that the apical leakage in group that was irrigated with 2.5% NaOCl alone (Group 1) showed the highest apical dye penetration. The group that lased with Nd: YAG laser (Group 2) showed less apical leakage, while the group that was irrigated with 17% EDTA followed by 2.5% NaOCl (Group 3) showed the lowest apical dye penetration.

NaOCl appears to be the ideal irrigant as it covers the requirements for endodontic irrigant more than any other known compound. Hypochlorite has the unique capacity to dissolve necrotic tissues (Naenni et al. 2004).

The results of this study indicate that the application of 2.5% NaOCl alone in group1 did not prevent the apical leakage and this comes in agreement with Medici and Froner, (2006) who showed that irrigation with NaOCl alone has the worst cleaning capacity in the removal of the smear layer and more apical leakage was noticed in these irrigated root canals.

This can be explained according to Baumgartner et al. (1987) and Oconnell et al. (2000) who found that using NaOCl alone for irrigation produces clean canal walls while the smear layer still present, also Prabhu et al. (2003) showed that NaOCl failed to remove the smear layer from the middle and apical third of the root canal, and therefore there was more apical leakage.

This is due to the fact that sodium hypochlorite cannot dissolve inorganic dentin particles and thus does not prevent the formation of a smear layer after instrumentation, though it appears to be the most desirable single endodontic irrigant (Zehnder et al. 2006).

The removal of smear layer is extremely important because its presence causes a series of undesirable effects, i.e., obstructs dentinal tubules, shelters microorganisms and does not allow close contact between the canal walls and the sealer and subsequently more apical leakage (Gettleman et al. 1991), (Hulsmann et al. 2003). Therefore, its absence makes the dentin more conducive to a better and closer adaptation of the gutta-percha and the sealer to the canal wall (Prabhu et al, 2003).

Pallares et al. (1995), Kouvas et al. (1998) and Kokkas et al. (2004) showed, that when the smear layer was not removed, no penetration of the sealers into the dentinal tubules could be achieved and so more apical leakage be occurred.

Andreas et al. (2004) and Shahravan et al. (2007) also concluded that smear layer removal improves the fluid-tight seal of the root canal system.

Furthermore, smear layer removal from the canal walls before obturation significantly reduced the apical leakage of root canal sealers as reported by; Economides et al. (1999), Cobankara et al. (2004).

Success in the clinical usage of Nd: YAG laser largely depends on the wavelength, output power, pulse duration, exposure time, spot size, type and color of tissue which will be irradiated. The (helicoidal) movements that were employed permitted the irradiation of the entire surface without great temperature increase (Gutknecht et al. 1996), (Arisu et al. 2004).

The temperature reached by the dentinal structure is also related to the power and other parameters of the laser, such as: frequency, timing of radiation, amount of energy. The higher these parameters, the larger will be the increase in temperature (Fraunhofer, 1993).

The results of this study show that the group in which application of Nd: YAG laser to root dentin surface (group 2) cause decrease in the apical leakage in all of the teeth sealed with the four sealers used in comparison with (group 1) and this comes in agreement with Goya et al. (2000), Dhanalakshmi, (2005) and Netto et al. (2007) who found that Nd: YAG laser decreased apical leakage in treated teeth in comparison with teeth that were untreated with this laser. Marques et al. (1995) showed that the pulsed Nd: YAG laser has the ability of melting the dentin wall in a root canal and disturbing of smear layer that decrease apical leakage.

Moreover, Haapasalo et al. (2005) showed that Nd: YAG laser promotes clean dentinal walls, capable of removing the smear layer entirely.

Their conclusion was that the smear layer may have lost its effect or may have been eliminated by the application of laser.

But the results is disagreing with Levy, (1992) ,Miscerendino et al. (1995) and Saunders et al. (1995) who observed that partial or complete obliteration of the openings of lateral canals besides the dentinal tubuli that affected the obturation and hence no effect on the apical leakage in lased root canals. However, it should be highlighted that the power employed by these investigators was much larger than that of the present study.

EDTA is widely used as a chelator in endodontic therapy. It is used at various concentrations and combinations in root canal treatment. The efficiency of such agents depends on many factors, such as the root canal length, penetration depth of the material, hardness of the dentin, duration of application, the pH, and the concentration of materials (Galt and Serper, 2000).

The results of this study indicate that the irrigation with 17% EDTA followed by 2.5% NaOCl (group 3) has least apical leakage compared to the group irrigated with 2.5% NaOCl alone (group 1), this comes in agreement with Farhad and Elahi, (2004) who found that the apical leakage was decreased in obturated canals when they irrigated the canals with EDTA followed by NaOCl.

EDTA followed by NaOCl have an efficacy to remove the smear layer as reported by Baumgartner and Mader, (1987), Sen et al. (1995), and Murray et al. (2008).

Vasconcelos et al. (2007) and Ricardo et al. (2007) also indicated that the combination of NaOCl and EDTA completely removed the smear layer from dentinal walls. While NaOCl only is not as efficient in cleansing the root canals and removing of smear layer completely.

This is due to the fact that NaOCl alone is an organic solvent that will remove the organic material from the smear layer, while irrigation with EDTA removes the inorganic portion of smear layer, therefore to eliminate the smear layer completely;

EDTA should be followed by an organic solvent such as NaOCl (Yamada et al, 1983).

Furthermore, EDTA followed by NaOCl open the dentinal tubules by the demineralization of peritubular dentin that leaves the dentinal tubules widely open causing the penetration and mechanical locking of sealers into dentinal tubules and increasing the adhesion surface area between canal wall and filling materials and therefore increasing in the apical seal and subsequently decreasing the apical leakage (Manoel et al. 2002), (Farhad and Elahi, 2004), and this explains why in (group 3) less apical leakage was seen than that found in (group 1) and (group 2).

In (group 2) that applied with Nd: YAG laser showed more apical leakage than (group 3) which using 17% EDTA followed by 2.5% NaOCl with all four sealers. This can be explained according to Kaitsas et al. (2001) who demonstrated that the root canal walls of teeth that irradiated with an Nd: YAG laser showed a clear glazed surface, some open dentinal tubules, and some surface craters with cracks. However, it is difficult to clean all the walls of a root canal by application of this laser, and if the energy level and duration of application are inadequate, a certain degree of thermal damage and morphologic changes in dentin structure are observable.

Also, Villegas et al. (2002) showed that some dentinal tubules were partially obturated when the root canal wall irradiated with an Nd: YAG laser, probably due to the inclusion of air bubbles during obturation, and also because of the presence of some portion of smear layer that might partially obliterate the dentinal tubules in the root canals that were lased with Nd: YAG laser. Gurbuz et al. (2008) point out that EDTA solution and Nd: YAG laser groups showed lower scores for debris and smear layer than NaOCl irrigation only. They found clean root canal wall with only few small debris particles, cracks, and open dentinal tubules in a group that was lased with Nd: YAG laser. In the group that irrigated with EDTA, they found clean root canal wall, no smear layer, and all the dentinal tubules are opened, while they showed debris and smear layer on the root canal surface that obscured the dentinal tubules in the group sample that was irrigated with NaOCl only, and that explained the result of the present study.

Conclusions:

The lowest mean apical leakage was obtained by using (17% EDTA followed by 2.5% NaOCl), while the highest mean leakage was obtained by (2.5% NaOCl alone), with using all sealers.

Statistically there was no significant difference between the group that was irrigated with (17% EDTA followed by 2.5% NaOCl) and the group that was applied with (Nd: YAG laser) with all sealers.

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