Scanning Electron Microscopic And Apical Leakage Evaluation Of Three Different Apical Plugs Treated With Glass-ionomer Root Canal Sealer

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Abstract:

In this study forty-eight single rooted premolar were used. In each root canal apical isthmus was prepared 1mm in length at 1mm short of the anatomical apex. The prepared root were divided into four equal groups according to the type of apical plug material. In control group, dentin chips without glass-ionomer sealer was used as apical plugs, while in the other three groups the roots were plugged apically with dentin chips, enamel powder and hydroxy-apatite crystals, respectively, mixed with glass-ionomer root canal sealer. The sealability of the different apical plugs was evaluated by methylene blue dye. SEM was used to evaluate the adaptation as well as the surface structure of the apical plugs. The results of this study showed that the hydroxy-apatite crystals apical plug with glass-ionomer sealer was superior to other control and experimental groups. On the other hand, the enamel plug with sealer showed poor resistance to dye penetration as well as poor adaptation to dentinal wall.

Introduction:

The most common cause of endodontic failure can be attributed to the lack of an apical seal[1]. Many investigators have recommended the use of dentin apical plugs acting as apreventing barrier at the apical foramen[2], to avoid overextension of the filling materials[1]. Moreover, the dentin plug filling encourage hard tissue formation[3,4]. However, some investigations have been less favorable to this technique, reported that leakage was greater in teeth with dentin plugs than without[5]. To improve its sealing property, Hasegawa et al [6], made an attempt to treat the plug with bonding agent.

ESPE CO introduced a new glass-ionomer root canal sealer in endodontics. It has been reported to be cover the almost of ideal requirements of root canal sealer described by grossman [7-10]. One of the most important properties of glass-ionomer is a chemical binding to dentin resulting a better ability to seal retrograde cavities than the traditionally used amalgam[11].

Calcium phosphate or hydroxy-apatite early used in endodontics to induce apical closure in human permanent pulpless teeth with large open apices[12]+. It has been shown to be compatible to hard and soft tissues[13]. Roberts and Brilliant[14], found that tricalcium phosphate was effective as calcium hydroxide to promote apexification by stimulating hard tissue formation. The seeds growth of calcium phosphate on dentin and predentin reported that the mineralization reaction of organic and inorganic dentin was induced in vitro at physiological changes during growth very similar to that observed for synthetic hydroxy-apatite[15]. So it was encourage to use this material as root canal filler[16].

The aim of this study was to evaluate the effect of using glass-ionomer root canal sealer as chemical bonding agent on the sealability and adaptation of thre different apical plugs(dentin, enamel and hydroxy-apatite).

Materials and Methods:

Forty-eight freshly extracted single rooted lower premolars were selected and stored in normal saline solution, for 24 hours before using. The crown of each tooth was decapitated at cemento-enamel junction. The working length was determined, 1mm short of radiographic apex. Apical isthmus was prepared 1mm in length as described by Hasegawa et al [6]. After payency of the apical foramen with #15 K-file, first apical seal was prepared with # 45 K-file at the working length, and then second apical seat was prepared with # 60 K-file at 1mm short of working length. During preparation, the canal was irrigated with normal saline ensure patency of the apex with # 15 K-file.

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The canal was dried with paper points. The prepared roots were divided equally into four groups, twelve roots each.

First Group(Control Group):

In this group, the apical isthmus of each root canal was plugged with dentin chips. By using # 60 H-file, the canal wall was filed, then the generated clean dentin chips packed into the apical isthmus with the same file under hand pressure[4,6].

In the other three experimental groups, glass-ionomer root canal sealer (ESPE pharmahandel GmbH, Ratinizgasse 20b,0-8060 Dresden) was used to chemically bond the apical filling particles, dentin chips, enamel particles as well as hydroxy-apatite crystals, respectively.

The Second Group:

After trituration of glass-ionomer capsule for 8 second, one drop of sealer was inserted in the apical isthmus of each root by using suitable size reamer, then the dentin chips were forced apically using file # 60 to fill the apical isthmus.

The Third Group:

In this group, fresh clean enamel powder was collected by grinding the sterile crown enamel. The enamel powder was forced apically using # 60 K-file after application of sealer to the apical isthmus of each root canal as described before.

The fourth Group:

In this group, the apical isthmus was plugged with hydroxy-apatite crystals (Ceramed Corp., 12860 West Cedar Drive Lakewood, Colorado 80228), after insertion of root canal sealer.

After filling the apical part of each canal with different apical plugs, the remainder of canal was obturated with laterally condensed gutta-percha and glass ionomer sealer.

For leakage test, ten roots of each control and experimental groups, were painted with several layers of nail polish, leaving the apical foramen uncoated. The apex of each root was exposed to methylene blue solution at room temperature for 1 week. The roots were then rinsed properly for 1 minute with distilled water and sectioned longitudinally to measure the depth of dye penetration using magnifying lens. The results were recorded, statistically compared and evaluated by one way analysis of variance and T-student tests.

The other two specimens of each group, were examined by SEM to evaluated the interface between the different apical filling and dentin wall as well as the surface structure of each individual apical filling material.

Results:

The dye penetration of specimens of each group were measured and statistically compared. Table (1) represents the means and standard deviation values for all tested groups. Hydroxy-apatite exhibited the lowest mean leakage (0.17mm), table (1).

Figures 1-4 showed examples of apical leakage in four tested groups. By one way analysis of variance statistical test, there was no significance difference between the four tested groups (F value=2.68597 at $p< 0.05$), table (1).

Each two groups were then compared statistically by T-test. We found that hydroxy-apatite with glass-ionomer root canal sealer was significantly the best apical filling as compared with dentin chips without sealer (t= 2.5381), dentin with sealer (t= 2.5559) or enamel with sealer (t= 3.3836), table (2).

While there was no significant between the remaining three tested groups, table (2).

By SEM, we examined each individual plug and the interface between it and canal walls. In the control group, the dentin chips appeared separated with big spaces Fig.(5). Some gaps were seen at the interface between dentin plug and canal wall Fig. (6). In the second group, when the

glass-ionomer applied to dentin plug, the dentin particles showed with various sizes and sealer filled some spaces between the particles with evidence of chemical reaction at the peripheries of dentin chips, while other spaces still present between the dentin particles Fig.(7). At the interface of this obturating material and canal wall, there was line of demarcation with close adaptation to the canal wall. The material appeared to be flow into the surface irregularities of dentin wall with evidence of chemical reaction between sealer and root canal dentin Fig (8).

Table (1): Representing the means of dye penetration, standard deviation and standard error values of all tested groups.

Tested Groups	Dentin Without bond	Dentin With bond	Enamel With bond	Hydroxy-apatite With bond
Mean	0.84	0.65	1.0	0.17
Standard Deviation	0.8979	0.8949	0.8279	0.2059
Standard Error	0.2592	0.2583	0.9390	0.0595

F value = 2.69597 not significant difference at $p < 0.05$

Table (2): Representing the statistical significant difference among four tested groups, according paired t-test at $p < 0.05$

Insignificant Difference	Significant Difference
• Control group versus the second group (t=0.5237). Control group versus the third group (t= 0.4491). The second group versus the third group (t= 0.9945).	Fourth group versus the control group (t= 2.5381). Fourth group versus the second group (t= 2.5559). Fourth group versus the third group (t= 3.3836).

Fig (1): Representing the apical dye penetration in the Control group (dentin apical plug). Note the penetration of dye through the plug.

Fig (2): Showed the apical dye penetration in the specimen Plugged with dentin chips and glass-ionomer root canal sealer. The depth of dye reach most of the Plug length.

Fig (3): Showed dye penetration in specimen plugged with enamel powder and glass-ionomer root canal sealer. The dye penetrates the whole length of the plug.

Fig (4): Representing dye penetration in specimen plugged Apically with hydroxy-apatite crystals and glass-

Ionomer sealer. The dye penetration is limited to the unfilled apical portion, while the apical plug was free from the dye.

Enamel plug material with glass-ionomer sealer (third group) showed complete fusion of grinned enamel and the sealer which appeared as big masses of sealer with embedded enamel particles Fig (9). At the interface, there was poor adaptation between the enamel plug and root canal wall Fig (10).

The hydroxy-apatite apical plug treated with glass-ionomer root canal sealer (fourth group) was observed with reaction zone around the irregularly shaped crystals Fig (11). The lower magnification (X 800) at the interface between plug and canal wall revealed excellent adaptation to the dentin wall, flow of the material into surface irregularities of dentin and precipitation reaction looks like brush heop structure was also observed, Fig (12).

Fig (5): SEM photomicrograph of specimen plugged apically with dentin chips. The dentin particles showed with various particle sizes, voids and big spaces seen between particles Mag (x 2000).

Fig (6): SEM photomicrograph of interface between dentin plug and canal appeared to be not well adapted Mag (x 800).

Fig (7): SEM photomicrograph of dentin aplical plug with glass-ionomer root canal sealer, showed with well defined dentin particles with different sizes big spaces can be seen between the particles. Note the sealer masses which fill some of the spaces Mag (x 2000).

Fig (8): SEM photomicrograph of the interface between the dentin plug with glass-ionomer sealer and canal walls showed close adaptation Mag (x 800).

Fig (9): SEM photomicrograph of enamel plug with glass-ionomer sealer showed big masses of sealer with embedded particles Mag (x 2000).

Fig (10): SEM photomicrograph at the interface between enamel Plug with glass-ionomer and root canal wall, showed poor adaptation Mag (x 800).

Fig (11): SEM photomicrograph of hydroxy-apatite plug with glass-ionomer sealer showing large crystals, reaction zone all around the crystals resulting in irregular surface appearance of the crystals Mag (2000).

Fig (12): SEM photomicrographof the interface between hydroxy-apatite crystals treated with glass-ionomer sealer and canal wall showed excellent adaptation Mag (x 800).

Discussion:

Many investigators have recommended the use of sterile dentin filling as apical plug representing one of the biological root canal filling material[3,4]. AS regards to the ability of apical plug to seal the apex, few articles reported that the dentin plug itself had poor apical seal property[6].

Our study showed that dentin plug alow relatively more dye penetration than that treated with glass-ionomer root canal sealer, although there is no statistical significant difference. By scanning electron microscope, we observed big gaps, separating the dentin particles of control group, also some gaps seen at the interface between dentin plug and canal wall. This gaps may allow dye penetration and resulting in poor sealing ability of control group. When glass-ionomer sealer used with dentin plug, SEM revealed close adaptation of plug material to the canal wall and the sealer appeared to be flow into the surface irregularities of dentin wall with evidence of chemical bonding between sealer and dentin wall. This result may concerned to the basic advantage of glass-ionomer cement which is the chemical binding to dentin[7,11].

Ray and Seltzer[7], stated that the reaction of glass-ionomer cement and tooth structure is a simple inorganic reaction in which the calcium ion of the tooth is released by epoxy acrylic acid component of the cement. This released free inorganic ions complex with the tartaric acid of the cement, facilitating the cross linkage of the polyacrylate chains.

Also, Hasegawa et al [6], reported that the bonding agent can improve the sealing ability of the plug due to the sealing of the microspace which exists between dentin filling itself and at the interface between the plug and canal wall. However, it might cause toxicity to tissue in direct contact with periapical tissue. On the other hand, the glass-ionomer appeared to improve the sealing ability, while it also reported to be biocompatible material without interferance with the surrounding periapical tissues[8].

In this study, three different apical plugs material containing different particle size were selected, the grinned enamel represents the smallest particle size, dentin chips represents the medium particle size, while the hydroxy-apatite represents the largest particle size. Through the leakage study, the enamel plug group recorded the maximum mean value of leakage followed by dentin plug group, while the hydroxy-apatite group recorded the least mean apical leakage. However, a statistical significant difference was not determined between the four tested groups. Otherwise, by t-test statistical analysis, the hydroxy-apatite with glass-ionomer root canal sealer was significantly the best apical plug used.

This result can be attributed on the basis of SEM study, where the hydroxy-apatite plug showed good adaptation at the interface with evidence of chemical reaction between the sealer and dentinal wall as well as between the hydroxy-apatite crystals and glass-ionomer sealer. This opinion can hold our observation, wher increase the resistance of dye penetration through the hydroxy-apatite group. On the other hand, the large size of the hydroxy-apatite crystals may be enhance the chemical reaction between the sealer and crystals by providing large surface area for reaction. At the same time, the insertion of this big crystals to the apical isthmus force the sealer to sealer to dentinal walls resulting in good adhesion between sealer and dentinal walls.

Again, the enamel plug exhibited poor resistance against methylene blue penetration, and SEM observation showed the grinned enamel particles embedded inside big masses of sealer. This result may be attributed to the fine particles of the grinned enamel which failed to bond chemically with the sealer. On the other hand, it may also be failed to force sealer strongly to adapt and adhere well to dentinal walls of apical isthmus, resulting in poor adaptation of enamel plug to dentin wall with subsequent poor sealing ability.

Summary and Conclusion:

Forty-eight extracted single rooted lower premolar were used. After crown decapitation, apical isthmus was prepared in each root canal 1mm in length . First apical seat was prepared with # 45 file at 1mm short of the anatomical apex , then the second seat was prepared 2mm short of the anatomical apex by using # 60 file. According to the type of apical plug material, the prepared root were divided into four equal groups. In control group, dentin chips without glass-ionomer sealer was used as apical plugs, while in the other three groups the roots were plugged apically with dentin chips, enamel powder and hydroxy-apatite crystals, respectively, combined with glass-ionomer root canal sealer as bonding agent. The sealability of the four apical plugs was evaluated by methylene blue dye, while the adaptation as well as the surface structure of the apical plugs were evaluated by SEM.

From the results, we noticed that the hydroxy-apatite crystals apical plug with glass-ionomer sealer was significantly the best apical plug used. On the other hand, the bonding agent improved insignificantly the sealability of dentin plug as well as the adaptation of the plug to dentin wall. The enamel plug with sealer showed high apical leakage and poor adaptation to dentinal wall. However, hydroxy-apatite experimental group represented good adaptation at the interface with evidence of chemical reaction between the sealer and dentinal wall on one hand, and between the hydroxy-apatite crystals and glass-ionomer sealer on the other hand.

Finally we can concluded that:

1- Glass-ionomer root canal sealer may improve the sealing property of dentin apical plug due to its chemical binding property to dentin.

2- Hydroxy-apatite crystals with glass-ionomer sealer can be used as apical material as it reported significantly the best resistance for dye penetration and appeared with good adaptation to dentin wall.

3- Enamel apical plug with its fine particle size, has poor sealing ability as well as poor adaptation to canal wall.

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