Evaluation of Three Resin-Based Root End Filling Materials in Surgical Endodontics

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Abstract: Surgical endodontics becomes necessary when conventional therapy is not feasible or successful. The most frequently performed procedures; in this situation is apicoectomy and retrograde filling in the resected root end. The purpose of this study was to compare between the sealing abilities as well as the working time of three root end filling materials; self-adhesive cement (Rely X Unicem) and composite resin (Tetric Ceram composite resin) combined with two different types of two-step bonding agents, etch-and-rinse (Excite- Ivoclar-Vivadent)versus self-etch (Clearfil SE-Bond-Kuraray) systems. Methodology: thirty recently extracted human, permanent single-canalled teeth were selected for this study. Endodontic access cavity preparation was done in all teeth, and finally coronal access was sealed with composite .Teeth were randomly assigned into two equal groups :Group A(no bevel) **:** 3 mm of the roots were resected in a plane perpendicular to the long axis of the tooth with no bevel , and then Class I root-end cavities were prepared using fissure bur to the depth of 3 mm parallel to the long axis of the root .Group B (45^0bevel): 3 mm of the roots were apically resected using high-speed carbide bur at 45^o beveled plane labio -lingually and then Class I root-end cavities were prepared **.**Each group was further subdivided into 3 subgroups of 5 teeth each according to the material used. Teeth were immersed in2% methylene blue dye for a period of twenty four hours, after which they were retrieved, washed, sectioned and the apical dye penetration were measured. Also the working time was measured for each material**.** Results: the results showed that RelyX groups had the best sealing abilities and the minimum working time, followed by Clearfil SE-Bond and Excite groups.

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1. Introduction

Endodontic therapy has played an important role in maintaining the integrity of the natural dentition as a fully functional and esthetic masticatory apparatus [(1)]. Although the sealing of the root canal system is usually accomplished by the conservative endodontic approach, cases which have failed or which involve perforations, internal resorption, broken instruments, or post-crown restorations, neglected, or improper treatment of traumatized anterior teeth, almost always treated surgically by root end resection and the placement of root end filling material. [(1-3)]The purpose of apical access, root resection, and curettage is to remove irritants from the root canal system inaccessible to the operator via a coronal entry, preparing a root-end cavity and filling it with a suitable restorative material prevents any remaining irritants from migrating into the periradicular tissues. [(4-6)]

An important consideration in endodontics is the ultimate seal of the root canals to prevent microleakage that may cause the root filling to fail. Microleakage can be considered as the passage of bacteria, fluids and chemical substances between the root structure and any type of fillings .This occurs because of microscopic gaps at the interface between the filling materials and the tooth[(7)].Microleakage in the root canals is complicated as many variables may contribute to it such as anatomy and the instrumented size of the root canal, irrigating solutions, root filling techniques, physical and chemical properties of the filling materials and sealers and the infectious state of the canal as well as smear layer removal and dentin permeability. Another complicating factor is the bleeding during material placement [(4)].

Establishing a retrograde seal after apicoectomy is essential to maintain an effective barrier between the root canal and the periapical tissues when a conventional orthograde seal is not possible or is suspected to be less than intact. Apart from selecting the sealing material, two factors which are under the direct control of the operator these are the depth of cavity for retrograde filling and the angle of resection. Several studies have showed that increasing the depth of a retrograde filling decreased apical leakage and increasing the bevel increased apical leakage as more dentinal tubules will be exposed [(8-10)].

Several materials were proposed as root-end fillings, historically, amalgam was the most commonly used material, however, mercury toxicity

has been deterrent its selection as a root end filling material [11]. Other alternatives like resin based materials and biological materials as MTA are now widely used [12]. An ideal root-end filling material should produce a complete apical seal, has antibacterial activity, and be nontoxic, biocompatible, nonabsorbent, dimensionally stable, easy to manipulate in a minimum time, unaffected by moisture, and be radiopaque[13] .Composite resins were used as a root-end filling material but they seemed to be subjected to microleakage. To prevent microleakage the use of dentin bonding agents had been proposed [14]. Bonding agents could compensate for the polymerization stresses increasing the sealing ability of the composite to the radicular dentin [15].

Contemporary dentin adhesives were classified into three-step, two steps, and single-step systems depending on how the three cardinal steps of etching, priming, and bonding to dentin were accomplished. The three-step systems required acid etching, rinsing, priming, and application of an adhesive. The two-step systems were subdivided into self-priming adhesives that require a separate etching step and rinsing . The second is the self-etching primers that require an additional bonding step. The single-step adhesive systems contain a mixture of acidic monomers that could both prime and bond dentin, all in a single application[16-17].

The introduction of self-etch self –adhesives, made use of acidic monomers that simultaneously condition and prime enamel and dentin and provide vinyl groups for co-polymerization with the resin composite. The bonding mechanism of self-etch adhesives was based upon changing the chemical composition of the substrate surface, commonly referred to as hybridization; the surface layer of dentin was partially dissolved and the resultant porosity filled by resin[18] .

Although , Bouillaguet et al., 2007[19] reported that self-etch adhesive had improved bond strength and better sealing ability,Taschner et al.,2011 [20]found no significant difference between self-etch adhesives cement and a total-etch resin cement systems after four years of clinical use. Self-etch adhesives were reported to be time consuming and less technique sensitive, in particular with regard to keeping the dentin surface in an adequate state of hydration and less nanoleakage[21-23].

Therefore, purpose of the current study was to compare between the sealing abilities as well as the working time of three resin –based root end filling materials with different angulations of beveling of the resected root.

2. Materials and Methods

Thirty recently extracted human, permanent single-canalled teeth were selected for this study.

The selected teeth were free from coronal or radicular caries or restoration. Also there was no presence of resorption, fractures, or cracks. All the teeth had maturely formed root apices and patent to size 15 file. All teeth were scaled with curettes and polished with polishing brushes to remove any bone, calculus or soft tissue attached to the teeth. Root canal length was determined by inserting a # 15 K-type file into the coronal access of the canal and advancing it apically until it became visible at the apical foramen. This length, minus 1 mm, was recorded as the working length. The root canals were enlarged at working length to a minimum size of 50 K-type file, used in a circumferential filling motion .The irrigant solution was 20 ml of 0.5% NaOCl (Rioquı´mica Ltd., Brazil) for each tooth. After being cleaned and shaped, canals were dried with paper points (Endopoints Ind. Co., Ltd., Brazil) and obturated with laterally condensed gutta-percha and Endofill (Dentsply, Brazil) and finally coronal access was sealed with composite (Ivoclar,Vivadent-Liechtenstein). Specimens were stored in saline solution for not more than one week until the moment of apical preparation. Teeth were, then randomly assigned into two equal groups (15teeth/group):

Group A (no bevel):

3 mm of the roots were apically resected ,using cross- cutting fissure carbide bur using high-speed hand piece with water spray, horizontally in a plane perpendicular to the long axis of the tooth with no bevel ,and then Class I root-end cavities were prepared using fissure bur to the depth of 3 mm parallel to the long axis of the root were prepared.

Group B (45^0bevel):

3 mm of the roots were apically resected using high-speed carbide bur at 45^o beveled plane labio-lingually and then Class I root-end cavities were prepared in the same way.

These groups were further subdivided into 3 subgroups according to root end filling materials used (5teeth each):

Subgroup 1:

The root-end cavity was filled with RelyX Unicem (3M, ESPE AG Germany) (Fig1).

Subgroup 2:

The root-end cavity was filled with composite after using etch-and-rinse bonding agent with primer and bond in single bottle (Excite- Ivoclar-Vivadent-Liechtenstein).

Subgroup 3:

The root-end cavity was filled with composite after using self-etch bonding agent with two-step

priming and bonding (Clearfil SE-Bond-Kuraray-medical INC. - Japan).

Root-end filling materials were mixed and handled according to the manufacturer's instructions and light-cured for 10 seconds using Light Emitting Diode (Flash Lite 1401 – U.S.A.).

Figure 1: RelyX Unicem application kit

Figure 2: A tooth with 45^0 root end resection bevel sectioned mesio-distally

The external surfaces of the roots were covered by two layers of nail polish except at the resected root end surface. Immediately after that, the microleakage test was performed.

Evaluation of sealing ability:

All examined group's roots were immersed in a 2% methylene blue dye in an upright position at room temperature for the period of twenty four hours [(24)]. After the period of examination passed, the teeth were removed from the dye then washed and left to dry. Roots were then sectioned longitudinally (fig 2) with a diamond disc mounted to a slow speed straight hand piece and the depth of dye penetration was measured in each of the tested specimens with the aid of magnifying lens and digital caliber .The linear dye penetration for each tooth was measured for each half of a root from right and left and the mean of the four readings was recorded in millimeters. The linear dye penetration for each tooth was measured twice at different times and the mean of the two readings was calculated

Measurement of working time:

Stop watch was used to measure the working time for each material from initial handling till the material set.

Statistical analysis:

Analysis was performed with SPSS 16.0 (Statistical Package for Scientific Studies).Paired sample t-test was used for comparison between groups and subgroups. The significance level was set at $P \leq 0.05$.

3. Results

Table (1) and Fig (3) show the means and standard deviations of the leakage values of all subgroups measured in millimeter. The mean leakage value for group A (no bevel) and group B (45^0 bevel) were 1.3±0.35 mm and 1.34 ±0.35 mm respectively, with no statistical significant differences between both groups (P = 0.233). Excite groups presented the worst apical sealing abilities as demonstrated by the highest degree of dye penetration compared to RelyX and Clearfil SE-bond groups (P<0.01), Although, RelyX groups, showed slightly lower degree of dye penetration than Clearfil SE-bond groups, difference was not statistically significant (P = 0.55) .

As regard working time of the three tested materials, it was found that RelyX group had significantly lower working time (mean 45 seconds± 4) than both Clearfil SE-bond (133 seconds ± 12) and Excite groups (mean 167 second ± 11), p=0.0.The differences between Clearfil SE-bond and Excite groups was also significant (p=0.05) Fig(4) .

Table (1) : Means in millimeters and standard deviations of the leakage values of all subgroups

Materials	Group A(no bevel)	Group B(45^0 bevel)	Total mean
RelyX	1.06 ± 0.001	1.1 ± 0.001	1.08 ±0.001
Excite	1.76 ± 0.11	1.8 ± 0.16	1.78 ±0. 13
Clearfil SE-bond	1.08 ± 0.001	1.12 ± 0.001	1.1 ± 0.001
Total mean	1.3±0.35	1.34 ±0.35	1.32 ±0.34

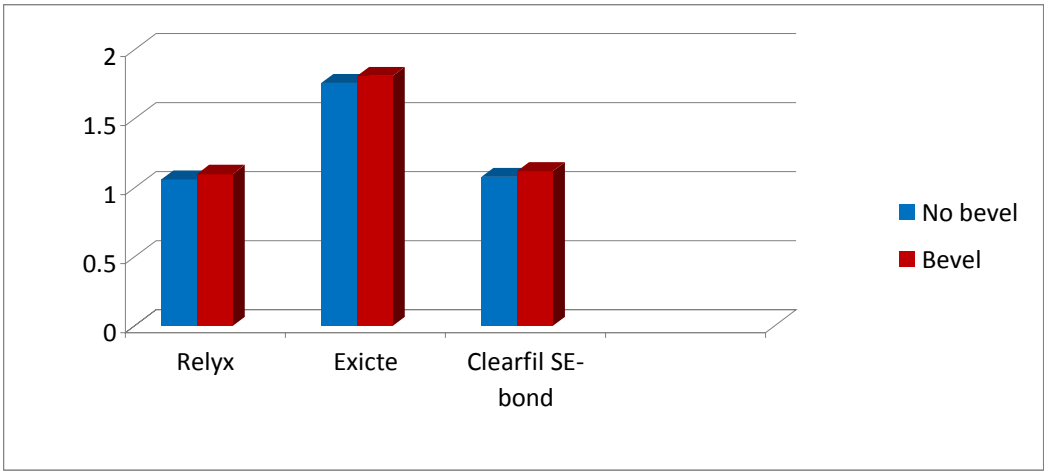

Fig. 3: The length of dye penetration in millimeters

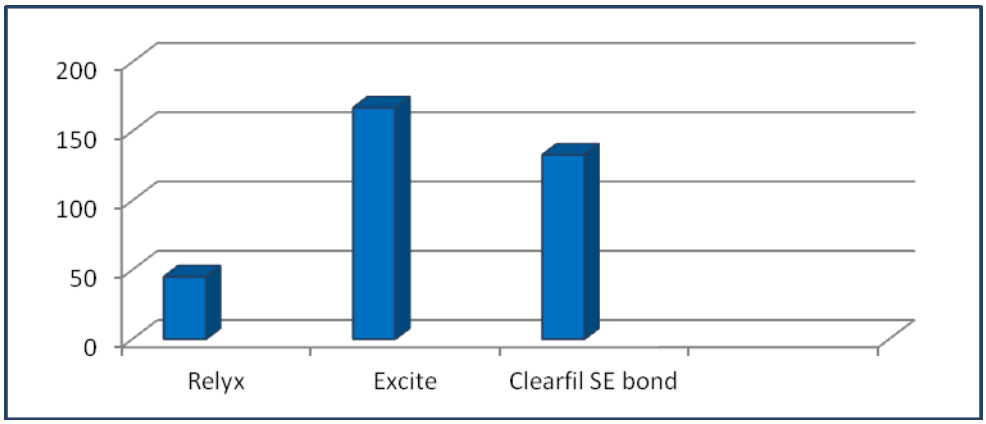

Fig.4: Working time in seconds for the tested materials

4. Discussion

Despite advances in endodontic materials and techniques that aim to achieve a totally sealed root canal system, root canal fillings demonstrate microleakage over time. Many materials have been used for root-end fillings in endodontic surgery. However there is no one material that is universally accepted as the best. Resin based materials are now a day used as root end filling material together with bonding agents to compensate for the polymerization stresses increasing the sealing ability of these materials to the radicular dentin [14,15].

The current study was conducted to compare the sealing abilities as well as the working time of three resin based root end filling material ; a self-adhesive cement (Rely X Unicem) and composite resin (Tetric Ceram composite resin) combined with two different types of two-step bonding agents. The first type was etch-and-rinse bonding agent with primer and bond in single bottle (Excite- Ivoclar- Vivadent). The second type was self-etch bonding agent with two-step priming and bonding (Clearfil SE-Bond-Kuraray).They were tested by dye penetration for their sealing abilities with different angulations of beveling of the resected root (no bevel & 45^{o} bevel).

The apical leakage of retrograde filling materials has been studied by using dyes [25], electrical current [26], bacteria [27], and by a fluid transport model [11]. Methylene blue dye is one of the most common methods for measuring the extent of dye penetration as it has a very small molecular weight [23,24,28,29]. Therefore, it was used in the present study to evaluate sealing ability of the tested materials

There are many variables may contribute to microleakage in the root canals such as anatomy and the instrumented size of the root canal, irrigating solutions, root filling techniques, physical and chemical properties of the filling materials and sealers and the infectious state of the canal as well as smear layer removal and dentin permeability. Another complicating factor is the bleeding during applying materials [6]. These entire variable were standardized for all groups except for the filling materials, therefore leakage could be related to the tested material only.

Several studies showed that increasing the depth of a retrograde filling decreased apical leakage and increasing the bevel increased apical leakage. [9] Fogel et al., [30] reported that an apical preparation of a depth of 3 mm yielded less leakage than if the preparation were shallower, in the present study class one cavities were prepared to a depth of 3mm in all resected roots.

Although, main goal of adhesive dentistry is to promote an effective, durable, seal of tooth hard tissues, all adhesives presented a certain degree of micro-leakage with notable differences [31]. The results of the present study revealed that no of the tested material was capable to provide a leak- proof seal. However, sealing abilities of the three materials differ; Relyx exhibited the best sealing ability followed by Clearfil SE bond and lastly Excite group. No statistical significant differences in sealing abilities of RelyX and Clearfil SE bond groups, This is in agreement with Taschner et al.[20] and Schenke et al. [21] Clearfil SE bond (two-step self-etching primers)showed better sealing ability than Excite (two-step etch and rinse),a finding that goes in accordance with *Armstrong et al.* [16] *and Korasli et al.* [32] and *Reisa et al.* [33], yet disagreed with *Frankenberger et al.* [34] *and Perdigão et al.* [35] who found that the sealing ability of composite resin bonded with 2-step total etch bonding agents was higher than the sealing ability of composite resin bonded with 2-step self-etching bonding agents. On the other hand, Piwowarczyk et al[36] and Reich et al[37] , found no significant difference between self-etch adhesives cement and a total-etch resin cement system

Since water plays an important role in both etch-and-rinse and self-etching bonding approaches [38]. Thus, different water sorption rates might be expected for the adhesives tested in this study [39]. The worse sealing ability exhibited by etch-and-rinse systems may be attributed to regions of incomplete resin infiltration or polymerization, which represent potential pathways for fluid penetration [40]

The results of the current study also, showed that there was no significant difference in sealing ability of beveled and non beveled groups. This may be due to the sealing of the cut dentinal tubules by the tested materials . Comparable results were reported by *Tsesis et al.*[41] , *Gagliani et al.*[42]*and Lloyd et al.* [43] A finding support previous studies suggesting that the most appropriate angle of root-end resection is to be perpendicular to the long axis of the tooth. *Gilheany et al* [10] found that the sealing ability was better with the non beveled roots than 45^0 beveled roots because of the exposure of less dentinal tubules with the non beveled roots.

Working time is a very important factor for proper sealing of any material in presence of bleeding during surgery .Etching increases bleeding, rinsing with three ways syringe can also introduce blood to the cavity. This will make adhesion to the cavity wall nearly impossible. It was found that RelyX had the least working time (mean 45 seconds+ 4), it needs no etching, nor rinsing, it also showed the best sealing abilities, it can be considered a good root-end filling material. While the longest working time was for Excite groups (mean 167 seconds +11) in addition to etching which increases bleeding and rinsing may introduce blood to the cavity, it also had the worst sealing ability, it can be considered a poor root-end filling material. Except for its long working time (133 seconds ± 12) Clearfil-SE-Bond can be considered a good root-end filling material, combination of etchant and primer into one system is advantageous in that it reduces the application time and technique-related sensitivity [44]. This was in agreement with similar studies conducted by Korsali et al. [32]; Xavier, et al. [45] and Er , et al [46] .

Conclusions

1. No material tested in this study was capable of providing a leak-proof seal.
2. Relyx presented an excellent sealing ability and minimal working time compared to Clearfil SE bond and Excite groups
3. Excite group had the worst sealing ability and the longest working time of all groups .

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