Chapter Five

Discussion

5.1 Methodology

5.1.1 Tooth Collection

There are numerous types of solutions used for storage of the extracted teeth. It ranges from water to solutions prepared to prevent bacterial growth, such as formalin, sodium azide in saline, sodium azide in water, thymol, aqueous chloramine and 3% sodium hypochlorite (DeWald, 1997). Although these storage and disinfection materials would render as ideal conditions for extracted teeth handling, there are some concerns about compositional or structural alterations of enamel and dentine (ColombiHumel, 2007).

In this present study 0.5% chloramine T solution was used as disinfectant solution of the samples for one week as recommended by ISO standard (ISO/TS 11405:2003).

Chloramine T solution has been recommended as infection controlling for research purposes, because it did not show any adverse effects on the organic phase of dentine. Also, the microleakage tested around composite restoration was similar to freshly extracted teeth (ColombiHumel, 2007). Then, the samples were stored in distilled water in a refrigerator (4°C) with the water changed once every week.

5.1.2 Tooth Selection

A total of 70 lower premolar teeth with a single root canal were used in this study. Buccolingual and mesiodistal radiographs were done and the criteria for tooth selection were straight, single-rooted teeth with caries and fracture-free roots and patent canals. In this study, the root length, buccolingual and mesiodistal dimension were standardized to avoid variation in the specimens.

5.1.3 Root Canal Preparation

The main objectives of root canal therapy are cleaning and shaping and then obturating the root canal system in three dimensions in order to prevent reinfection (Torabinejad et al., 2003). Preparation of the root canal system is considered as one of the most important stages in root canal treatment.

In this current study, the samples were prepared by using the step-back technique which is the most common recommended method for straight canal preparation. 3.0 ml of a 5.25% sodium hypochlorite (NaOCl) was used for canal irrigation and smear layer removed between each instrumentation. Sodium hypochlorite has been recommended as an irrigant solution in the treatment of infected root canals at different concentrations because of its well-known bactericidal action (Siqueira et al., 1997).

Sodium hypochlorite has been demonstrated to be an effective agent against a broad spectrum of bacteria and to dissolve vital as well as necrotic tissue (Hülsmann and Hahn, 2000). However, using sodium hypochlorite in high concentrations will produce greater cytotoxicity when in contact with periapical tissues. It is known that the greater the concentration of sodium hypochlorite used, the greater will be its power to dissolve any tissue and its capacity to deactivate toxic products within the root canal system (Yamazaki et al., 2010).

After instrumentation, the canals were irrigated with 3.0 ml of a 17% ethylenediaminetetraacetic acid (EDTA) for removing the smear layer. EDTA is the most widely used chemical regarding removal of the intra canal smear layer (Prabhu et al., 2003). Final irrigation with EDTA will result in higher bond strength values because the effective removal of the smear layer by EDTA allowed for the extension of the resin into the open dentinal tubules leading to efficient microretention (Hashem et al., 2009).

Furthermore, Scelza and others (2004) have reported that 3 min irrigation with 17% EDTA presented the largest number of open dentinal tubules in comparison with other irrigants. Finally, irrigation was done with distilled water in order to remove any trace of irrigants left in the canal.

In this present study, all the specimens were obturated using lateral condensation technique. Even though, advances have been made in alternate obturation techniques, lateral condensation technique is still one of the most frequently used techniques (Clinton and Himel, 2001).

Less material extrusion using this technique was found in comparison with other obturation techniques (Mente et al., 2007). Moreover, significantly less microleakage was observed in teeth obturated with the lateral condensation technique. This could be because of the feasibility of introducing more accessory cones for lateral compaction, which, in turn, reduced leakage (Altundasar et al., 2008).

Resin-based root-canal sealers have been used for many years with clinical success. Sealers based on epoxy resins provide very good physical properties and ensure adequate biological performance (da Silva Neto et al., 2007).

In this study, non eugenol epoxy resin based sealing cement was used as a sealer (Pulpdent Root Canal Sealer,Coltene/Whaledent, USA) as substantial loss of retention had been reported when eugenol was used with resin-based cement; because eugenol has harmful effects on resin compounds (Alfredo et al., 2006).

Moreover, Hagge (2002) found that resin-based cements should not be used with eugenol-containing materials because the phenolic components of eugenol would interfere with the resin curing.

5.1.4 Post Space Preparation

During the preparation of the post space, it is important to maintain the integrity of the apical seal. In this present study, the teeth after obturation were stored in a 100% humid environment at 37°C for 24 hours to ensure full setting of the sealer.

However, some studies have stated that the sealing ability was not affected when post spaces were prepared either immediately or were delayed (Bodrumlu et al., 2007); others also reported that immediate removal of gutta-percha resulted in less leakage when compared with delayed removal (Cobankara et al., 2008).

Gutta-percha removal can be achieved by several techniques including chemical technique using different types of solvents, ultrasonic method, rotary instruments, hand instruments and heated instruments (Bodrumlu et al., 2007).

In this present study, the gutta-percha was removed with Gates-Glidden burs #3 and #4 using low speed hand piece. However, Solano et al. (2005) reported that there is no difference between thermal, chemical and mechanical removal of gutta-percha. On the other hand, Fouad (2004) stated that organic solvent such as chloroform is not recommended to be use in post space preparation because it is impossible to control their advance into the canal which can rapidly dissolve the gutta-percha and sealer at deeper level than anticipated.

Four mm of gutta-percha was left in this current study as apical seal. It is commonly believed that the remaining part of the root canal filling provides an adequate seal. Moreover, it is supposed that the seal provided by that minimal remaining root canal filling of 4-5 mm does not differ from that of the intact root canal filling (Abramovitz et al., 2000).

However, if the post is shorter than the coronal crown, the prognosis is considered unfavourable because the stress will be distributed over a smaller surface area (Fouad, 2004).

In this study, the post spaces of all specimens were prepared by using matching drills which were provided by the manufacturer to obtain standardization. This drill was used to obtain the final depth of post which was equal to 9 mm from the sectioned root surface, as 9 mm is equal to two thirds of 14 mm root length.

5.1.5 Post Cementation

In this present study, the post was cemented following the manufacturer's instructions accurately to obtain similar procedures as those done in the clinic.

A reliable bonding to root canal dentine is not easily achieved and the establishment of a valid micromechanical intraradicular bond is certainly challenged by several factors (Ferrari et al., 2007).

A study by Macedo et al. (2010) has shown that regardless of the type of cement used, increasing the depth of cementation is beneficial to improve the post retention. Moreover, a closer contact between cement type and dentine is important to improve the frictional retention of the post as a higher post-to-root canal adaptation increases the sustained pressure during cementation which results in better contact between the cement/post assembly and the dentine.

There are several methods for placement of cement into the canal including placement of the cement with a lentulo spiral, paper point or an endodontic explorer, but some studies have shown that using the lentulo spiral is the superior instrument for cement placement (Fouad, 2004).

In the current study, the posts were seated in the canal to a full depth with gentle pressure applied for a few minutes to allow an adequate adaptation of the posts and escape of excess cement.

An adequate polymerisation of luting agent is necessary to provide its mechanical properties that clinically ensure post retention. It has been reported that the mechanical properties of dual-cure type resin agents appear improved after photo-activation compared with chemical-activation alone (D'Arcangelo et al., 2008).

5.1.6 Post Systems

In this study, two different post systems were used: one, a fiber post which is Fiber Lux ParaPost (Coltene/Whaledent, USA) and the other, a titanium post which is ParaPost XH (Coltene/Whaledent, USA). Fiber Lux ParaPost is made of a translucent, light-transmitting unidirectional glass-fiber in resin matrix. This allows immediate fixation to dual- and light-cured resin cements and core materials using light polymerization, without any pre-treatment required to the post. It provides micro- and macro-mechanical retention to dual- and self-curing resin cements and composite-based core materials to ensure for a homogeneous restoration.

According to the manufacturer, the flexural strength of ParaPost Fiber Lux is approximately 1600 MPa. This high value indicates that it is more resistant to fracture and the modulus of elasticity is similar to that of dentine (45 GPa). This low modulus of elasticity enables the post to absorb stress rather than transfer it to the tooth.

One of the advantages of the ParaPost Fiber Lux is the radiopacity material which allows the post to be seen clearly on a radiograph. ParaPost XH is made from Ti6AL4V titanium alloy which is twice as strong as pure titanium. The rounded edges of the head minimize stress points that could lead to core failure.

Titanium posts concentrate stress close to the post-cement interface. Silva et al. (2009) studied the influence of different post designs and composition on stress distribution. They concluded that titanium posts concentrate stress close to the post-cement interface, promoting weakness of the restored tooth. The stress concentration of titanium posts was due to the difference in the stiffness between the post and its surrounding material (core, cement and dentine).

Thus, fiber glass posts can be considered a very good choice for post-endodontic restoration because of three main attributes: It gives good biomechanical performance because post, core, cement and dentine constitute a homogeneous ensemble; it provides excellent aesthetics, which makes it suitable for restoration in anterior region and it shows good adhesion to cement agents (Akkayan and Gulmez, 2002).

5.1.7 Thermocycling

Thermocycling is a widely using ageing technique. Evaluation of microleakage must include thermocycling in order to simulate intraoral conditions.

Korsali et al. (2008) stated that adhesive systems and resin composite restorative materials are sensitive to thermocycling. The stress from thermocycling may induce a significant amount of bond fatigue and microleakage at the tooth-restoration interface. Marginal leakage is believed to be the result of a difference in coefficient of thermal expansion between restorative materials and tooth.

Temperature extremes for in vitro thermocycling have ranged from 0°C to 68°C. These are assumed to be consistent with the minimum and maximum temperatures found in the oral cavity (Rossomando et al., 1995).

In this present study, the teeth were thermocycled for 500 cycles at 5°C for cold bath and 55°C for the hot bath with exposure in each bath for 20 seconds and 5 seconds was the transfer time between the baths.

The International Organization for Standardization ISO/TS 11405:2003 indicates that a thermocycling regimen comprising 500 cycles in water between 5 and 55°C is an appropriate artificial ageing test. However, this number of cycles is probably too low to achieve a realistic ageing effect (Yuasa et al., 2010).

Rossomando et al. (1995) suggested that there was no significant change in the leakage pattern when the specimens were thermocycled and compared to specimens that were not thermocycled. However, Wahab et al. (2003) found that thermocycling significantly increased the microleakage of Class V composite restorations and the thermocycling was the most influential factor in enhancing the process of microleakage.

5.1.8 Evaluation of microleakage

5.1.8.1 Preparation prior to immersion in dye solution

In this study, before immersion in the dye solution, all the specimens were coated with a double layer of nail varnish to cover the entire root surface except for 2 mm coronally. After the second layer of varnish was dried, the specimens were covered with a tin foil and the apical foramen was sealed with sticky wax to prevent apical leakage of the dye solution.

Sadeghi (2007) suggested that prior to the microleakage test, the apices of the samples should be sealed with utility wax and the tooth should be painted with two coats of fingernail varnish to prevent dye penetration from unnecessary foci.

5.1.8.2 Microleakage test

Dye penetration has been the most common in vitro method for evaluation of microleakage. Many dyes have been used as tracers in microleakage studies but methylene blue dye at various concentrations is the most popular (Fox and Gutteridge, 1997).

A large number of studies (Brandão et al., 2001; Kontakiotis et al., 2001; Camps and Pashley, 2003) used methylene blue as dye because it is inexpensive, easy to manipulate and has a high degree of staining. In addition to that, it has greater penetration than Indian ink. Methylene dye can penetrate through any space between the canal walls and filling material (Veríssimo and Do vale, 2006).

In this present study, methylene blue dye with concentration 2% was used as the leakage marker. Farea et al. (2010) have suggested that Methylene blue dye has a comparable leakage to butyric acid which is a metabolic product of microorganisms. Fox and Gutteridge (1997) noted that methylene blue dye penetrates further along the root canals than does Indian ink and suggested that this was because of methylene blue's low molecular weight.

5.1.8.3 Sectioning of specimens

There are different methods of splitting the root, such as longitudinal sectioning method, transversal sectioning method and tooth clearing method. It was suggested that the technique of making cross sections perpendicular to the long axis of the root can evaluate the quality of the root canal filling and any lateral canals, secondary canals, or cracks could be seen at the level of each of the cut specimens (Farea et al., 2009).

In addition, it was reported by Veríssimo and Do vale (2006) that longitudinal sectioning technique seemed to be the choice of the cut axis and the probability of the sectioning being made through the deepest dye penetration point, with consequent underestimation of leakage and recording of unreliable data.

A potential problem that had occurred in previous studies which used transverse sectioning was loss of tooth substance on preparing the horizontal sections but using of a very fine diamond saw (0.3 mm diameter), which cut slowly and less pressure under lubrication, enabled the amount of tooth substance lost to be minimized (Wu et al., 2000).

In this study, the readings were taken after a cross-section of each sample perpendicular to the long axis of the root into discs 1mm thick with water cooled diamond disc of 0.3 mm. This has allowed quantitive measures of the dye infiltrated area and total canal surface area in square millimetres, which were then the percentages of leakage calculated and compared statistically as recommended by Farea et al. (2010).

5.1.8.4 Assessment of Microleakage

From review of the literature, it is noted that various methodologies are available for assessing microleakage. However, linear dye measurements are the most widely used method for measuring dye leakage. This measurement show how far the dye has travelled through the canal (Farea et al., 2010).

Many researchers have evaluated microleakage using the linear dye penetration method (Aminozarbian et al., 2009; Uysal et al., 2009). It was found that there is a real lack of technique standardization between workers to such an extent that it becomes difficult to compare between similar techniques using slightly different apparatus, including the use of different dyes (Veríssimo and Do vale, 2006).

A linear coronal dye penetration was used in this study because it was easy to apply, fast, economical and the most commonly employed method for determining microleakage of adhesive systems (Uysal et al., 2009).

5.2 Results

One of the objectives of successful endodontic treatment is the total obturation of the root canal system. To achieve this, the root canal filling must seal the canal walls both coronally, apically and laterally in order to prevent the ingress of microorganisms or tissue fluids into the canal space (Farea et al., 2010).

Coronal microleakage has been cited as a major reason for root-canal treatment failure and much emphasis is now placed on the quality of the final restoration (Fox and Gutteridge, 1997).

Several factors could affect microleakage of posts systems including some variables that could be only controlled partly by the operator: morphology of canal system, the volume of prepared root canals, presence and character of the smear layer, the distribution of sealer, the condensation of gutta-percha cones, incomplete removal of sealer from intra-canal post space, luting process, distribution of cement in post space and operator error. Furthermore, the patency of dentinal tubules, dentine surface area of the canal walls and the remaining dentine thickness could affect microleakage (Rogic-Barbic´et al., 2006)

Numerous studies have evaluated the sealing ability of root canal fillings using methods such as dye leakage, electrochemical techniques, bacterial penetration measurement, radioisotope techniques and fluid filtration (Carratu et al., 2002). However, the dye

penetration technique is the most commonly employed method for determining of microleakage (Uysal et al., 2009).

In this study, the control group (RCT group) showed more dye penetration coronally and overall the leakage of this group was the most among the 3 different types of cement. The mean values of coronal microleakage of resin cement groups were comparable to zinc phosphate groups and glass ionomer groups. Overall the glass ionomer groups showed the lowest mean value of coronal microleakage among the different types of cement. However, there was no significant difference between the 3 types of cement statistically.

Bachicha et al. (1998) evaluated the microleakage of different cements in endodontically treated teeth restored with post system. They reported that no significant differences were found between the stainless steel post cemented with resin cement and the stainless steel post cemented with the glass ionomer cement.

Piwowarczy et al. (2005) evaluated microleakage of 6 different types of cementing agents. They concluded that the greatest degree of microleakage was observed with the zinc phosphate cement. The greater leakage of the resin cements compared to the conventional glass ionomer cement and the resin-modified glass ionomer cement may be thus attributed to polymerization shrinkage of the resin cements.

In contrast with the resin cements, conventional glass ionomer cements like Fuji I are considered to be more dimensionally stable during setting.

Rogic-Barbic´et al. (2006) investigated the microleakage among Glassix fibre posts cemented with three different materials. They concluded that the control group which is obturated with gutta-percha cones only exhibited the highest values for microleakage compared to resin cement and glass ionomer cement.

Wu et al. (1998) reported that the detaching of the root canal sealer from the dentine or gutta-percha caused by setting shrinkage may result in many voids along the filling. In a short filling, the voids may be more easily connected with one another than in a long filling and can permit leakage over the full length.

Although established protocols are used to simulate the oral environment, it is too complex to fully reproduce the real oral environment experimentally. On the other hand, it is reasonable to assume that the data obtained in the various study groups constituted a viable basis for comparison. In clinical practice, however, additional factors such as biocompatibility, thermal/electric conductivity, ease of use, and, most important, the specific requirements of each case must enter the equation to find out which cementing agent is most appropriate (Piwowarczy et al., 2005).

Leakage of root canal fillings, root-end fillings, or temporary coronal fillings has been widely studied (Aminozarbian et al., 2009; Ishimura et al., 2007; De Moor and Hommez, 2002). In contrast, leakage of cemented post in root canals has rarely been studied.

In this present study, the coronal leakage between post and cement comparison for different types of post systems and RCT group showed that the fiber post groups allowed less dye leakage and overall showed the lowest leakage among the metal post groups and RCT group. Statistically, there was significant difference in microleakage between Fiber Lux ParaPost (fiber post) and ParaPost XH (metal) and between Fiber Lux ParaPost (fiber post) and RCT group but there was no significant difference between ParaPost XH (metal) and RCT group.

The results of the present study are in agreement with the results of the study by Reid et al. (2003) who evaluated the microleakage of teeth restored with metallic posts cemented with zinc-phosphate cement and four types of non-metallic posts cemented with resin cement. They concluded that the metallic post group has a statistically significant increase in microleakage in comparison with non-metallic post group.

On the other hand, Bachicha et al. (1998) compared fluid filtration microleakage along metal posts and carbon-fibre posts cemented with different materials and reported that there was no significant difference in microleakage between the metal and the carbon-fibre posts.

Fogel (1995) intended to evaluate the microleakage of various post systems using a fluid filtration procedure. The post systems tested were stainless-steel posts cemented with zinc-phosphate cement, polycarboxylate cement, a composite resin, a composite resin after use of dentine-bonding agent and composite resin after the use of a dentine conditioner and dentine-bonding agent. None of the post core systems tested was capable of consistently achieving a fluid-tight seal.

Glass fiber post systems have elastic modulus lower than metallic post and their mechanical characteristic is similar to the dentine. This type of post might have distributed stress over a wider surface and limited microfracture inside the luting agent which resulted in less microleakage (Usumez et al., 2004).

5.3 Limitations of the study

1. One of the most difficult parameters to control in this study was the extent of anatomical variations that are present in human teeth. (More than 100 extracted mandibular premolars were examined to obtain the study samples).
2. The microleakge test in this study was applied to extracted teeth which might differ from intraoral condition. This result may differ from those done in vivo.
3. This study did not include the placement of a crown which may have an effect on the coronal dye penetration.

Chapter Six

Conclusion and recommendations for Further studies

6.1 Conclusions

The following conclusions may be drawn from this study:

1. The fiber posts displayed lower coronal microleakage compared with the metal posts and RCT group.
2. There was no significant difference in coronal microleakage between different types of cements in endodontically treated teeth restored with different post systems.
3. All tested groups presented different degree of coronal leakage and no cements were found to completely prevent microleakage.

6.2 Clinical recommendations

From this study:

1. Since the fibre post displayed lower coronal microleakage than the metal post, it becomes more recommended clinically. .
2. Since there are no coronal microleakage differences between resin cement, glass ionomer cement and zinc phosphate cement, clinically it is therefore better to use the cement with less technique sensitivity which is the glass ionomer cement.

6.3 Recommendation for further studies

Further studies that can be done are:

1. Evaluation of coronal microleakage of luting cements with crown.
2. Study of coronal microleakage in endodontically treated teeth restored with different post systems and amalgam core.
3. Comparing between longitudinal and cross-sectional technique in evaluation of coronal microleakage.
4. Evaluation of coronal microleakage of endodontically treated teeth restored with different post systems and composite core after cyclic loading.